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DEPRECIATION AND VALUATION FOR RATE CONTROL

SUMMARY

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I. Introductory — The Problem of Depreciation

In a review of current literature on public utility valuation published in a recent issue of this journal,[1] I reserved for later treatment one phase of the subject, the importance and difficulty of which seemed to require a separate article — the problem of depreciation. In its significance for the utility companies this question now far overshadows all others. Even the choice between reproduction cost and historical cost as a basis of appraisal is of less consequence than is the choice between some form of cost new and some form of cost depreciated.[2] One may readily understand the strenuous effort

1. "Progress and Poverty in Current Literature on Valuation," Quarterly Journal of Economics, vol. xl, pp. 295-328 (February, 1926).

2. Several of the more far-sighted public utility representatives are already entertaining serious doubt whether a prolonged period of falling prices may not turn the tables and make the historical cost of utility properties exceed the cost of reproduction. See, for example, Nash, The Economics of Public Utilities (N. Y., 1925), chap. 7.

with which public utility counsel are attempting to win their case for undepreciated appraisals, when one recalls that depreciation, figured on a "straight-line" basis, tends to reach as high a rate as 50 per cent of the cost new in the case of a diversified and well-established property.[3] Rapidly growing properties, to be sure, would be subject to no such drastic deduction, because of the large proportion of relatively new units of equipment. But even here the accrued depreciation, if computed on a straight-line or even on a sinking-fund basis, would amount to a very material fraction of the entire capital investment.

The fact that most business assets begin to depreciate from the moment when they are installed, and the necessity of making proper financial provision for their ultimate retirement, are so generally recognized in the business world of today, that any claim on the part of utility companies for a valuation undiminished by a deduction for depreciation might well seem too absurd to merit serious attention. Indeed, most of the utility advocates themselves do not go to the extreme of insisting on the complete exemption of their investment from all depreciation charges whatsoever. A distinction is drawn between "realized" depreciation—which may concededly be deducted in the determination of the rate base—and "accrued," or "theoretical," depreciation, which, it is claimed, cannot fairly be deducted. Realized depreciation represents the loss of efficiency to which the property has already been subject in consequence of the wearing out of the structure and equipment. Accrued depreciation represents the mere loss of life-expectancy of the operating units. An automobile, for example, after it has been used for several months, may have suffered no realized depreciation,

3. Somewhat less than 50 per cent, owing to the item of scrap value.

because it is still giving as satisfactory service as when it was new; but it has undergone an accrued depreciation, because a part of its useful life has already expired. Yet this latter depreciation, it is contended, should not be taken into account by public service commissions in fixing the value of the property for rate-making purposes.

It is by means of the above distinction that utility counsel hope to minimize the force of the judicial precedents which supporters of depreciation are able to muster against them. On at least one occasion the United States Supreme Court has declared that, in fixing rate-making values, commissions should reduce the "value new" by the amount of the depreciation.[4] But just what is meant by the ambiguous word, "depreciation," and just how it should be computed, has never been made clear by the highest tribunal. It is therefore open to argument, at least, that what the Court refers to is merely a figure representing loss of operating efficiency rather than a figure representing loss of life-expectancy.[5]

If the propriety of deducting accrued depreciation were denied only by public service representatives, one might fairly pass over the argument as a mere ingenious invention of a partisan mind. This, however, is by no means the case. Support for the position of the utilities has been forthcoming both from the engineering profession and from the academic economists. In 1912 the late Mr. James E. Allison, then engineer for the St. Louis Public Service Commission, published a special

4. Knoxville *v.* Knoxville Water Co., 212 U. S. 1 (1909). This position is reaffirmed, in the recent case, McCardle et al. *v.* Indianapolis Water Co., November 22, 1926, 47 Sup. Ct., 144.

5. See, for example, Nash, op. cit., pp. 176 ff.; Robert A. Carter and William L. Ransom, Depreciation Charges of Railroads and Public Utilities, A Memorandum Filed With the Depreciation Section of the Bureau of Accounts of the Interstate Commerce Commission (1921?).

report to the Commission defending with great skill the right of utility investors to a rate base equal to cost new rather than to cost depreciated.[6] Two years later Allison's position was reviewed and defended by Professor Allyn A. Young, whose article on "Depreciation and Rate Control," published in this journal, brought forth several replies and one rejoinder.[7] More recently there has appeared a monograph entitled *Depreciation of Public Utility Properties*, by Henry E. Riggs, Professor of Civil Engineering in the University of Michigan, which is largely an elaboration and defense of the theory set forth by Allison.[8] It is clear, therefore, that the case against accrued depreciation cannot be dismissed without a careful analysis of the points at issue.

The present article is written in the hope of clarifying some of the points of disagreement which developed in the discussion between Professor Young and his critics, and which have persisted in subsequent literature. As one of those who took issue with Mr. Young's position, I have become convinced that our disagreement was due almost entirely to the fact that we were reasoning from different premises. My own argument in support of the deduction of accrued depreciation assumed that cost of reproduction of the property or of the service was the accepted principle of rate control. Its conclusions as to depreciation were therefore derived from certain principles underlying the cost-of-reproduction method of valuation. Professor Young, however, has subsequently informed me that he, like Allison, was assuming the ac-

6. Should Public Service Properties be Depreciated to Obtain Fair Value in Rate or Regulation Cases? September 11, 1912.

7. Allyn A. Young, Quarterly Journal of Economics, vol. xxviii, p. 630 (1914); J. S. Davis and A. A. Young, Ibid., vol. xxix, p. 362 (1915); John Bauer, Ibid., p. 651 (1915); J. C. Bonbright, Ibid., vol. xxx, p. 546 (1916).

8. N. Y., McGraw-Hill, 1922. For a more recent discussion by the same writer, see H. E. Riggs, "Urgent Need for Revision of Our Conception of Depreciation," Aera, November, 1926, p. 592.

ceptance of some form of the historical-cost basis of rate control, and that his argument was not intended to hold good where a reproduction-cost standard is applied. Where cost of reproduction is the accepted standard, Mr. Young agrees that depreciation is a proper deduction. On the other hand, where a strict investment basis of rate control is accepted, I should agree that depreciation is quite irrelevant. The reasons why different premises as to the underlying principle of the rate base lead to different conclusions as to the treatment of depreciation will be discussed at length in this article.

II. The Case against Accrued Depreciation

Before considering separately the different types of rate base in their bearing on depreciation, I shall review briefly the "case against depreciation," as it is usually stated, often without specific reference to any one underlying theory of valuation. The argument, as developed by Allison, is based on a concept of the "organic unity" of a large operating plant. A public service property, like any other going plant, should be thought of, not as a mere sum of individual units of structure and equipment, but rather as an organic whole. The individual units, to be sure, wear out at irregular intervals and call for complete replacement at the end of their useful life. But the property as a whole behaves quite differently. As long as it is kept in good repair, and as long as its separate parts are replaced whenever they have ceased to be serviceable, it does not in itself undergo any depreciation. Altho it is tending constantly to grow old, its youth is being perpetually renewed. It remains, therefore, forever in the condition of being "as good as new."

If the above statements represent the true situation, they would seem to imply that a mature but well-maintained public service property, which is being valued *as*

a going plant for rate-making purposes, should not be subject to a deduction for the accrued depreciation of its units viewed as separate assets. Exception to this conclusion, it is argued, could be taken only on the ground that some reserve must be set aside in order to provide for the unit-replacements when they are necessary, and that a charge for depreciation should be made against the assets to correspond to this necessary reserve. To this exception, however, the anti-depreciationists reply that no reserve, or at all events no large reserve, is needed to provide for replacements. With a large and diversified property, such as the railroads and most of the local public service properties, the annual outlays for renewals tend to become fairly stable through the operation of the "law of large numbers." This stability, to be sure, is not present in a new enterprise. There is always a developmental period during which the replacement charges are abnormally small. But from year to year these charges grow, until they reach a period of "normal condition," of equilibrium, when they remain forever at a fairly constant figure.

From the assumed fact of this stability in annual retirement costs, Allison argues that no depreciation reserve is needed as a provision for the ultimate renewal of the structure and equipment. The renewals, being gradual and steady, can quite properly be charged directly against the operating expenses of the year in which they are made. To set up a depreciation reserve under these conditions would be to indulge in an extravagance similar to that of building a large storage reservoir for a hydro-electric plant, despite the fact that the flow of the river is sufficiently constant without any reservoir. The practice would impose upon the early customers of a public utility the burden of paying rates sufficient to build up a reserve not needed in order to maintain the property intact for the later customers.

One further significant inference is drawn by Allison. If rate regulation had actually commenced at the very inception of the present public utility enterprises, the question whether to deduct or not to deduct depreciation might have been settled in either way without affecting the rights of the utility investors. The only rights which would be affected are those of the earlier customers as compared with the later customers. As for the utility company itself, the policy of deducting depreciation from the rate base would not injure it, so long as it might claim the right to charge sufficient rates to set up an equivalent depreciation reserve. But rate control, unfortunately, has not begun until long after the birth of the utilities. Their early rate policies are things of the past and cannot be revised to conform to the present views of the regulating commissions as to how much depreciation should be written off by annual charges to operating expenses. It follows that a commission cannot now fairly deduct depreciation from the rate base unless the companies knew, or should have known, that this deduction might be expected, and that they must therefore offset the deduction by charging rates sufficient to amortize their investment, or to set up a depreciation reserve. But if it is admitted that accrued depreciation is a needless deduction—an extravagant luxury — then there is no reason to hold that companies should have anticipated its necessity. Consequently, the present belated attempt to base rates on cost depreciated rather than on cost new amounts to confiscation.

III. Current Criticisms of Allison's Argument

The defenders of depreciation as a fair deduction in a rate case have attempted to meet Allison's argument in

several different ways. Some writers have not thought it necessary to dispute his views as to the practical uselessness of a depreciation reserve, but have rested their case on the contention that the judicially accepted basis of rate control is the *real value* of the property, and that, since depreciation undoubtedly indicates a loss of real value, it must therefore be deducted. This argument will be examined later in connection with the use of reproduction cost as the basis of valuation. Meanwhile it may be noted that Allison himself forestalled this criticism by admitting that depreciation represents loss of market value but by denying that market value is the proper measure of the rate base.[9]

Another objection has been raised which meets Allison on his own ground. Actual experience, it is held, fails to bear out the assumption that public utility properties, as they exist today, are subject to fairly constant renewal cost. The theory of constant renewals holds good only under certain highly artificial conditions, among which is the condition that the cost of no single unit of structure or equipment shall constitute a significant fraction of the total operating expenses for any given year.[1] The nearest approach to the realization of these conditions occurs in the case of a large railway system. But even here there are large units, such as expensive locomotives, not to mention railway stations, the cost of which it would be impracticable to charge directly to the operating expenses of the year during which the renewal is actually made. When it comes to the case of a local public utility, such as an electric light company, the reliance on the "law of large numbers" to iron out the im-

9. Allison, op. cit., p. 21.

1. Dewing has enumerated four conditions which he holds to be essential to the realization of uniform retirement charges. Financial Policy of Corporations, rev. ed. (N. Y., 1926), p. 469.

portant fluctuations in annual replacement costs would be simply disastrous.[2]

So far as it goes, this criticism is, I think, conclusive. It is conclusive, that is, against the financial soundness of an accounting system which fails to set up any reserve to provide for future retirements of depreciable property. Taken by itself, however, it does not break the force of Allison's main contention, which is that there is no reason for deducting the *full "theoretical" depreciation*, based on a computation of the loss of average life-expectancy.

For if Allison and his followers are right in their assumption that the *only* reason for deducting depreciation lies in the necessity of setting up a stabilization reserve, then it follows that the amount of this deduction should not exceed the size of the reserve needed to secure stability. With the typical public utility, a reserve of 5 or 10 per cent of the total assets might well be ample to serve this particular function. At all events, no such huge reserve would be called for as would result from the accrual of depreciation on the straight-line basis, or even on the sinking-fund basis. The most that could be claimed, then, is that a public service commission, in arriving at the rate base of a utility, should deduct a small percentage from cost new, to represent the "real" depreciation as distinct from the much larger "theoretical" depreciation which results from the use of average life-tables.

But Allison's critics have not rested content with this modicum of victory, and they have adduced other arguments for the deduction of the full accrued depreciation.

2. Ibid., pp. 469 ff. This view is evidently shared by the Interstate Commerce Commission with respect both to telephone company accounts and railroad accounts. See its two recent orders, No. 14700, Depreciation Charges of Telephone Companies, and No. 15100, Depreciation Charges of Steam Railroad Companies.

They hold that, even accepting Allison's assumption of the stability of annual renewal costs on well-established properties, it would still be necessary to deduct accrued depreciation and to set up a corresponding depreciation reserve. What Allison's argument overlooks is that a reserve is necessary, not merely to stabilize the retirement charges of a plant after it has reached maturity, but also to equalize the burden of these charges as between the early years and the late years. If one waits until a retirement actually takes place before one charges any part of the cost to operating expenses, the expenses during the development period will be relieved of their proper share of the burden. As a result, the early customers will pay less and the later customers will pay more toward the upkeep of the property than they should fairly pay in view of their relative responsibility for the wear and tear of the plant. In short, exactly the same objection can be made to Allison's thesis that can be made to any accounting system which crudely computes annual income and expense on a realized basis rather than on an accrual basis.

The opponents of accrued depreciation, so far as I can discover, have not yet supplied an answer to this third type of criticism. Indeed, the more recent published arguments for their side of the case do not ever disclose an awareness of the nature of the criticism. This fact goes far toward confirming the position of the depreciationists, at least in so far as the whole case for or against the deduction is assumed to stand or fall with the validity of Mr. Allison's inferences from the notion of the "organic unity" of a large utility property.

But it is still possible that the anti-depreciationists may be right in their conclusions, even tho they may be wrong in their reasons for the conclusions. This possibility must now be discussed. The discussion, however,

will get nowhere unless it distinguishes between the different rate bases to which the factor of depreciation is meant to apply. It is of no use, for example, to argue that depreciation should be deducted because it represents a loss of *market value*, unless one accepts the position that market value is the proper test of the rate base as a whole. On the other hand, it is a waste of time to contend that depreciation does, or does not, represent a "loss of real efficiency," if the rate base is of a type which takes no account of plant efficiency in fixing the amount of the fair return. From this point on, therefore, I shall consider depreciation in connection first with one and then with another of the more generally accepted principles of rate control. The four following principles of rate control will be considered: (1) the strict-investment, or unrequited-sacrifice basis; (2) the present-value, basis; (3) the competitive-price or reproduction-cost-of-service basis; (4) the historical-cost basis.

IV. Depreciation where the Rates are based on the Strict Investment Principle

Discussions of public utility valuation frequently distinguish two rival bases of rate control — the actual-cost basis, and the present-value basis. Both of these terms are ambiguous; yet they do indicate two fundamentally different ways of arriving at a compensation for public utility services. According to the original-cost principle, public utility investors should be allowed a reasonable return on the amount of money which they have actually contributed to the public service.[3] According to the present-value principle, the basis of the return is not the amount actually contributed by the security holders, but rather some measure of the

3. This allowance is generally qualified by the condition that the investment shall have been a "prudent" one.

"value" of the property which is now being used for a public purpose. "Value," to be sure, is an ambiguous term, but when properly used it indicates that the measure of the property is, not its cost of production, but rather some measure of what it is now good for — an appraisal of benefits expected rather than of sacrifice incurred.

It is the actual-cost principle and not the present-value principle which is to be assumed in this section. But, here again, a distinction must be made. For the term "actual cost," or "original cost," is used in two ways: sometimes to refer to the contributions of the security holders, and sometimes to the actual cost incurred by the *company* in the purchase of its present property. It is only when used in the first sense that "actual cost" is a strict and uncompromising investment basis; for only in this sense does it refer merely to the pecuniary sacrifice of the investors rather than to the property possessed by the company. But if pecuniary sacrifice is the measure of the rate base, as it is under a strict investment principle, there may be included an allowance for any failure of the security holders to receive a reasonable interest during the past years of operation, and there may be deducted an allowance for any excessive returns over a reasonable interest. The resulting rate base — original contribution plus deficiencies and minus excessive profits — represents the "unrequited sacrifice" on which the fair return is to be computed.

For the sake of a convenient terminology, I shall hereafter refer to the rate base just described as the "strict investment" base, in distinction from the "historical-cost" base, by which is meant the actual cost of the existing property. Students of public utility regulation do not need to be reminded that the strict invest-

ment principle is almost never accepted without qualification in American systems of control, and that the principle has been repeatedly denounced in various decisions of the United States Supreme Court. Despite this fact, its implications cannot be ignored in a study of depreciation, because other current rate bases, notably the historical-cost basis, are nothing more than compromises between the strict investment principle and some other principle of rate control. It is, therefore, proposed to consider at this point the strict investment basis in its bearing on the problem of depreciation.

The discussion of this question, however, need hardly be longer than the famous chapter on snakes in Ireland. There *is* no depreciation on the strict investment principle. That is to say, the whole question of the condition of the physical property — whether it is new or old, whether it is modern or obsolete, even whether it is existent or non-existent — is irrelevant.[4] What the investors are entitled to is a fair return on their pecuniary sacrifice; or rather, what they are entitled to is freedom from governmental interference in charging such rates as will, if possible, yield them this fair return. It is only when, and to the extent that, government disregards the sacrifice principle and turns its attention from the funds invested to the property or services *resulting* from the investment that depreciation becomes germane to the problem of the rate base.[5] This is so obvious that it would hardly be denied by anyone who takes the time to think the matter through.

4. Except in so far as the strict investment principle is modified by the requirement that the investment shall have been prudently made and that the property shall have been prudently managed. If the depreciation indicates mismanagement, or lack of reasonable upkeep, it may be deducted to the extent that a capable management would have avoided it.

5. R. L. Hale, Valuation and Rate-Making (N. Y., 1918), p. 123.

V. Depreciation where the Rates are based on Cost of Reproduction as a Measure of "Present Value"

In marked contrast with the investment principle is the policy of fixing the rate base by reference to the cost of reproducing the property "used and useful" in the public service. It is in connection with this basis more than any other that the sharpest conflict has arisen over the question of depreciation. If cost of reproduction is accepted as the proper measure, should it be cost new, or cost minus accrued depreciation, or cost minus realized depreciation? The answer must depend entirely on an answer to the prior question, Why is cost of reproduction at all relevant as a measure of the fair return?

A study of valuation literature and judicial opinions indicates two quite distinct grounds on which cost of reproduction may be defended. The courts and the lawyers have generally taken one ground, the economists have almost invariably taken another. Looking at the problem primarily as one of protecting private property against "confiscation," the courts have held that the real test of the rate base is the "true value" of the property, and that reproduction cost is to be used merely as evidence — tho possibly dominant evidence — of this value. Looking at the problem primarily as one of attracting capital on the most favorable terms to the ratepayers, the economists, in so far as they have supported the use of reproduction cost, have defended it, not as a measure of the "value" of the property, but rather as a measure of the "normal" or competitive rate level. I do not mean to imply that these two notions have been kept entirely distinct. Indeed, there is little doubt that the courts have been more or less influenced by a com-

petitive price concept as buttressing their faith in a "present value" rate base. But at all events the two ideas are sufficiently distinct to require separate treatment in any attempt to discover the rationale of the reproduction-cost principle.

The present section will assume that cost of reproduction is used as a measure of the "present value" of the property, while the following section will view it as a measure of "competitive price." What, then, is meant by "present value"? The phrase suggests some measure of what the property is worth, what it is good for, as distinct from what it actually cost. But if we measure its worth by its market value as a going concern, we are involved in that hopeless vicious circle of basing rates on a value which in turn depends on the rates. If, on the other hand, we turn to the market values of the separate physical assets, in the sense of the prices at which these assets could be sold piecemeal, we get the equally ridiculous result of reaching a mere scrap value.

Writers on valuation have long been at pains to find some way out of this dilemma by discovering a third meaning of "present value," which is neither capitalized earning power on the one hand, nor scrap value on the other. Their efforts have not been altogether successful; but perhaps the most plausible suggestion is that the courts, when they refer to the "present value" of the property, mean the value of the physical plant as distinct from the value of the going business. This value may be thought of as the price which a utility company, possessing the franchise to operate, but lacking the necessary physical property, would be willing to pay for the plant of the company whose rates are now being determined.[6] It is presumed that such a plantless company would not be willing to pay more for the physical

6. Hale, Valuation and Rate-Making, chap. 3. Cf. also, Commons, Legal Foundations of Capitalism (N. Y., 1924), pp. 201 ff.

property than its cost of reproduction, since it would otherwise prefer to build a new plant instead of buying the old.

There are difficulties in this conception of "present value" as meaning the value of the tangible assets distinct from the intangible assets. And it may be chasing a will-o'-the-wisp to attempt to give precision to a concept which is anything but precise in the minds of the judges who use the term. For our present purposes, however, there is no need of pursuing the subject further, since it is quite clear that *any* notion of a physical valuation, if it has meaning at all, necessarily implies a deduction from cost-of-reproduction new, to allow for accrued depreciation and for obsolescence. It is nonsense to say that a dynamo of an obsolete type is *worth as much* as a dynamo of the most modern design. It is equally fallacious to claim that a plant which has undergone accrued depreciation is worth as much as a new plant. For the presence of this accrued depreciation means that the property has fully or partly outlived that early period when renewal costs are abnormally low, and that it has reached or approached the stage of "normal condition" where it is doomed, forever after, to incur relatively heavy (and relatively stable) annual outlays for replacements. It is only by disregarding this difference between the renewal burdens of a new and an old property that public utility counsel are able to make accrued depreciation appear to be merely "theoretical" and of no influence on the "real value" of the property.[7]

7. A recent writer on depreciation, while conceding the necessity of deducting depreciation when the rate base is made to depend on "present value," insists that the amount of this depreciation should be determined by observation, i. e., by inspection, rather than by resort to life tables based, necessarily, on the past experience. Hasbrouk, "When should Depreciation be deducted to find the Rate-Making Value of Public Utilities?" Cornell Law Quarterly, x, 471 (1925). There is no

The above points require qualification, however, in one important respect. Public utility representatives quite rightly insist that there are some respects in which an established plant, with a history of several years of operation, is worth more, rather than less, than a new plant. Solidification is an example of this kind, especially important with railway roadbed. In addition there are the advantages of having passed the experimental stage in the operation of the running mechanisms. All these advantages of maturity are necessary and proper factors for consideration in any rate base which involves a measure of the *value* of the physical property. They should either be included as a separate factor of "appreciation," or else they should be offset against the gross depreciation to show the net depreciation. But it is brazen impudence to insist, as some public utility counsel do insist, that only the one side of the equation should be considered, and that the utilities should be rewarded at one and the same time for the freshness of youth and for the ripeness of old age.

VI. The "Competitive-Price" Rate Base. Cost of Reproducing the Service

In the preceding section it has been assumed that cost of reproduction is considered merely as *evidence* of the

doubt that observation should be used as a check on "theoretical" depreciation as computed from life tables. But it is not alone adequate. For even a close inspection by skilled engineers will fail to reveal many kinds of physical deterioration which have not progressed far enough to affect outward appearances. No life insurance company, in deciding whether a particular candidate is a "good risk," would wish to rely wholly on a medical inspection without any knowledge of the age of the candidate. It would insist on basing its decision on a consideration of *both* kinds of data. The United States Supreme Court, however, in its most recent valuation case, indicates a strong preference for the observation method of estimate. "The testimony of competent valuation engineers who examined the property and made estimates in respect of its condition is to be preferred to mere calculations based on averages and assumed probabilities." McCardle et al. *v.* Indianapolis Water Co., November 22, 1926, 47 Sup. Ct. 144.

commercial or market value of the physical property, and the conclusion has been reached that under such an assumption depreciation should logically be deducted. It should now be noted that there is a much more sophisticated defense of reproduction cost as a rate base, a defense the full implications of which have been worked out only by economists and other specialists in valuation, but which, in a more or less vague form, has doubtless been of considerable influence in judicial decisions as to the proper basis of valuation. The defense is based on the "competitive price theory" of utility rates.

According to this theory, the object of public service regulation is to deprive utility companies of the power to charge a monopoly price. Rates should therefore be fixed at a level which they would probably reach if they were regulated, not by the fiat of government, but by the forces of normal competition. But under competitive conditions the prices of services and of commodities tend to equal their cost of reproduction. Therefore, under conditions of monopoly, utility prices should be made to equal the cost of reproducing the service rendered. And by "cost of reproducing the service" is meant the price which would just be sufficient to induce investors to put up a new plant and to give service similar to that given by the present company.

This is not the place to examine critically the full implications or the practical wisdom of the competitive-price theory of rate control. It has been developed and defended most effectively by two writers, the one an economist and the other a railway attorney.[8] Our present task is neither to condemn nor to praise, but simply

8. H. G. Brown, "Railroad Valuation and Rate Regulation," Journal of Political Economy, xxxiii, 505–530 (1925); F. G. Dorety, "The Function of Reproduction Cost in Public Utility Valuation and Rate-Making," Harvard Law Review, xxxvii, 173–200 (1923).

to observe what bearing its acceptance would have on the deduction of depreciation in a valuation case.

First, it must be noted that the primary test, under the competitive price theory, is not cost of reproducing the property, but rather cost of reproducing the service. We are to ask ourselves what schedule of prices would induce investors to incur the capital expenses and the operating charges of a new plant in order to get the business. We assume that these new investors would insist on a price sufficient to pay the operating expenses plus a current rate of return on their invested capital. And we are therefore under the necessity of estimating what the operating expenses would probably be, and what the invested capital would probably be. Neither the operating costs nor the capital investment of the present plant have any direct bearing on the case.

But instead of going on a mere dead reckoning of the operating expenses and capital charges of a new plant, it may be convenient to assume, as a first approximation, that the cost of production and the operating expenses of the new plant are identical with the estimated cost of reproduction and the operating expenses of the existing plant. It would not do, however, to accept these figures as final, for the new plant will be, not a replica of the old one, but rather the most efficient substitute, with modern types of equipment. Its operating expenses will, therefore, be less than the expenses of the old plant, and its capital costs per unit of capacity may also be less, altho they may possibly be more. Some modification of the first approximation must therefore be made to take account of these differences.

Altho this modification must take account of the differences both in the operating expenses and in the capital costs between the old plant and the new, it may be convenient as a short-cut method to allow for all these

differences by a mere adjustment of the rate base, — by some deduction from or addition to the cost of reproduction of the present plant, — and to include the operating expenses of the present plant without any modifying factor. In that case, the "fair rate of return" for any given utility would be such a return as would pay the actual present operating expenses plus a current interest rate on the cost of reproduction new, modified so as to allow for the differences in operating expenses and capital costs between the old plant and the hypothetical new plant. Two of these necessary modifications are, first, a deduction for "accrued depreciation," and second, a deduction for "obsolescence." Accrued depreciation must be deducted because it represents the disadvantage that the older plant suffers from the necessity of charging to its operating expenses the full "normal" renewal costs of a developed property instead of the light renewal costs of the unmatured plant. It is simply a capitalization of the temporary advantage enjoyed by the new property in the form of low replacement charges. Obsolescence is a similar deduction to offset the advantages of the modern types of machinery and structure — advantages that may take the form of lower operating costs or of lower capital costs per unit of plant capacity. Unless both of these allowances are deducted from the estimated cost of reproducing the present property, the resulting rate base would sanction rates of charge in excess of the cost of reproducing the service.

It is doubtless true that most of the public utility representatives who have written against the deduction of accrued depreciation from cost of reproduction new, would not concede that cost of reproducing the service is the proper or the judicially accepted criterion. They would therefore belittle any conclusion with respect

to depreciation that is derived from this hypothesis. These very writers, however, are themselves relying on a "competitive price" principle in their efforts to make out a case against the deduction. For they argue that the mere age of a plant ought to have no bearing on the prices which it may charge for its services. They assume the case of two utility properties, identical, save for the fact that the one property is new and the other is old, and they ask why the company which owns the older plant should be required to charge less for the same service than the company owning the new plant. They even reinforce their point by the *reductio ad absurdum* of picturing a dairyman reducing his charges for milk as the age of his cows increases, or a taxicab owner revising his meter charges downward as the life-expectancy of his cab is reduced.[9] As a matter of fact, these analogies lead to conclusions directly contrary to the ones which their inventors wish to draw. For it if be assumed that an old plant and a new plant should charge the same prices for their service, then the old plant must necessarily base its charges on a depreciated rate base in order to offset the fact that its operating charges will be higher. *Equality* of charge requires *inequality* of rate-making valuation.

In making the foregoing statements I do not overlook the undoubted fact that a new public utility enterprise is under one significant disadvantage which may partly or wholly offset the advantage of temporary freedom from "normal" renewals. That is the disadvantage of being without a developed business — in other words, without "going value." Going value, in this sense, is an item that must clearly be added to the "physical" valuation of a mature public utility property if the prin-

9. Robert A. Carter and William L. Ransom, op. cit., p. 10, quoting from a monograph by George N. Webster, Theoretical Depreciation, p. 9.

ciple of the "competitive price" is to be accepted as the basis of rate control. It represents the fact that a new, competing enterprise will not be started unless the promoters believe that the prices which they may charge for the service will yield, in later years, a return sufficient to compensate for the inadequate return expected in the early years. The existing, old property which is undergoing valuation, must be allowed to charge rates sufficiently high to tempt these hypothetical competitors to start from the beginning and to build up a new business.[1] The rate base for the old property must therefore be measured by cost of reproduction new, *plus* going-value, *minus* accrued depreciation and obsolescence.[2]

The conclusions to which this section and the previous section have led are substantially those which I reached in my earlier article written in reply to Professor A. A. Young's published defense of the anti-depreciationists.[3] They are the more confidently restated because, as I

1. It must not be assumed, however, that the "competitive price" principle requires an old enterprise to charge such a rate as would yield a tempting return to a new enterprise *during its early years of operation.* What the "competitive" rate must do is to tempt investors to set up new enterprises in view of the *average* profits to be expected during earlier and later years.

2. It may occur to the reader that if the "competitive price" principle requires such elaborate adjustments of the estimated reproduction cost as are called for in order to allow for depreciation, obsolescence, and going value, then it is too speculative and too costly a method of rate control for any practical purpose. Without being ready definitely to commit myself, I should be inclined to agree that the point is well taken. Critics of the cost-of-reproduction method of valuation have often pointed out that, if adopted at all, the method must on practical grounds result in an estimate of cost of reproducing a substantially identical property, with at best some very crude, partial allowances for the modifying items noted above. They therefore argue, with much reason, that all those static principles of normal price and economic balance which Brown and other writers adduce in support of reproduction cost are not likely to be even roughly adhered to under any method of physical valuation that would actually be arrived at by commissions and validated by courts. This contention, however, is beside the issue of the present article.

3. See p. 188, supra, note 7.

now find, they are shared by Professor Young, whom I erroneously assumed to support a contrary position. Professor Young has informed me that in questioning the propriety of a deduction for accrued depreciation, he, like Allison, was presupposing some form of the "historical-cost" basis of rate control. Granting the premises which underlie the reproduction cost base, he agrees, as I understand, that depreciation should be deducted. It is also significant that the two writers who have developed the most careful and elaborate economic defence of reproduction cost as the basis of rate control — H. G. Brown and F. G. Dorety — agree that accrued depreciation should be deducted from cost new.[4]

VII. Depreciation where the Rates are based on Actual Cost of the Present Property. The "Historical-Cost" Basis

Having concluded that depreciation is irrelevant under the strict investment principle, but that it is properly deductible under any principle which makes use of reproduction cost, I turn now to that compromise rate base which has already been mentioned but not discussed — actual cost of present property. It is this basis, often called the historical-cost basis, which is generally favored by those public service commissions which do not accept the standard of cost of reproduction.

First of all there is need to emphasize the fact, so generally overlooked, that the historical-cost basis is indeed a hybrid — a cross between the investment principle and a "present value" principle. While the former principle looks to the funds contributed by security holders, and the latter looks to the property resulting from the investment of those funds, the historical-cost basis takes a Janus-faced view of both circumstances.

4. See the references on p. 202, note 8.

In appraising the *present* physical property, it accepts the one criterion; but in basing this appraisal on *original* cost rather than on replacement cost, it accepts the other criterion.

Divided allegiances, despite proverbs to the contrary, are not always to be deplored; and it may well be that some compromise of the nature that has just been suggested would result in the most practicable rate base. But in arriving at such a compromise one must face the difficulty that a choice of the exact proportions in which to mix the two principles must often be made on arbitrary grounds, or at all events on grounds of expediency that cannot be justified on the basis of any simple logical formula. Precisely this difficulty is present in the choice between historical cost new and historical cost depreciated. It is quite impossible to deduce the validity of either the one choice or the other from any underlying principle to which all the details of the rate base must conform. With equal plausibility one may argue that depreciation *should* be deducted, because any basis that takes account of *present* physical property should also take account of the *present* physical condition of that property; or that depreciation should *not* be deducted, because a rate base which appraises the property at *original* rather than current prices should also appraise it as in its *original* physical condition rather than in its current physical condition.

The solution of this riddle, if there is any solution, must be sought in an answer to the further question, what is the rationale behind the use of actual cost of present property? If its use is defended, as some writers would seem to imply, simply as the best available evidence of the funds contributed by the security holders (the more direct evidence of the company accounts being notoriously inaccurate), then it follows that the choice

between cost new and some depreciated cost must depend on which of these figures seems more likely to approximate the historical contributions of the investors. And this question can be answered only by a study of the financial history of the company rather than by reference to any theory of depreciation. But if the historical-cost basis is accepted, not as a mere evidence of the original investment, but rather as a reasonable compromise between an investment basis and a reproduction cost or "present value" basis, then we are still without any premises from which to deduce the logical conclusion that depreciation either must or must not be deducted. And this agnosticism must persist until the proponents of the historical-cost basis have explained, as they have never yet satisfactorily explained, why any one particular type of compromise is better than any other type.

I have hesitated for some time before taking this skeptical position as to the propriety of depreciation under the historical-cost basis, in view of the fact that a much more positive stand is taken by John Bauer,[5] with whose opinions on utility regulation I am in general agreement. Bauer takes the position that, even with a historical-cost basis, depreciation should clearly and obviously be deducted, and he would apply this principle not only to future investments but also to the valuation of present properties. He points out that, according to the historical-cost principle, when a piece of property is completely retired, it ceases to be counted as an item in the rate base. Why, then, should another piece of property which has *almost* reached the retirement point and which is perhaps serving only as reserve equipment, be valued at its full cost rather than at some figure which represents its reduced usefulness? [6]

5. Effective Regulation of Public Utilities, chap. 7.
6. Ibid., p. 159.

Bauer's point certainly has force. But the difficulty is that its force is just as potent against the use of historical unit prices as it is against the use of historical (undepreciated) physical condition. If a dynamo is to be valued at less than its original cost when its style of construction has become obsolete, why should it not be valued at more or less than original cost when its price has become obsolete? In the one case the dynamo has become relatively inefficient because modern dynamos are better; in the other case it has become relatively inefficient because modern dynamos are cheaper. In short, unless we adopt either a 100 per cent investment standard, or a 100 per cent "present value" standard, we are forced to make some compromise which will involve striking inconsistencies of the type to which Bauer calls attention.

In this critique of Bauer's position I do not mean to assert that the particular compromise which he suggests — historical cost depreciated — is obviously the wrong one. All ex-post-facto rate bases are, at best, makeshifts. They must almost invariably make concessions to different and inconsistent considerations. They must give heed at one and the same time to the "reasonable expectations" of the early investors and to the very different "reasonable expectations" of the later investors in the same company. They must take account not only of the amounts which the original security holders contributed, but also of the prices which later purchasers had reason to believe (in view of the then prevailing theories of rate regulation) that they would be entitled to earn in the future. A compromise rate base is therefore almost inevitable. And it may be, altho I am at a loss to see why, that *original* cost of *present* property in its *present* physical condition is the best compromise. But in any case — and this is the

only phase of the subject with which I am here concerned — the wisdom of this particular compromise can be determined only by an artistic balancing of opposing considerations, never by a scientific deduction from any fundamental principle or indisputable fact pertaining to the process of depreciation.

Conclusions

The special object of this article has been to point out how impossible it is to discuss intelligently the proper treatment of depreciation except by reference to the underlying theory of valuation to which the depreciation policy is meant to apply. When rates, for example, are controlled on a strict investment basis, depreciation of the physical property is wholly irrelevant. On the other hand, when the charges are made to yield a return on the reproduction cost of the property, both accrued depreciation and obsolescence should be fully deducted. It is only under the compromise rate base, "historical cost" of present property, that the problem of deducting or not deducting depreciation admits of any reasonable doubt; and here, the practical choice must be left to those non-logical considerations of give and take which form the basis of most compromises.

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WHAT DO STATISTICAL "DEMAND CURVES" SHOW?[1]

SUMMARY

How statistical demand curves are constructed, 213. — The theory of the demand-and-supply curve analysis applied to a period of time, 217. — Statistical curves which would result under hypothetical conditions, 218. — Data used do not necessarily reflect influence of demand more than of supply, 222. — Whether fitted curve approximates a demand or supply curve depends on the relative *variability* of demand and supply, 224. — Slope of the fitted curve may not correspond to the true demand curve, 225. — In what sense may statistical demand curves be "general" demand curves? 228. — Distinction between consumer and dealer demand, 230. — Fitted curves are "static" in the sense of showing an "average" relationship, or relationship at a "typical" point of time, 231. — Do statistical demand curves assume all other things equal? 233. — Conclusions, 234.

MANY questions of practical importance hinge upon the elasticity of demand, or of demand and supply. The economist can answer them only in a vague and indefinite manner, because he does not know the nature of the demand curve. What will be the effect of a five-million-bushel increase in the corn crop upon the price of corn and of hogs? What will be the effect of a tariff on imports and prices; on the protected industry; on the balance of international payments? How large an indemnity can Germany pay? The answers all depend in greater or less measure upon the elasticity of demand of the various commodities in question.

1. The author is indebted to those who have read the manuscript while it was in various stages of completion. The criticisms of Professors Allyn A. Young, F. W. Taussig, and W. L. Crum of Harvard University, of Dr. C. O. Hardy of the Institute of Economics, and of Dr. H. Working of the Food Research Institute, have been particularly helpful. The charts were drawn by Mr. R. P. Ward of the Institute of Economics.

Such are the needs of the theorist, and in recent years a great deal of attention has been turned to the construction of statistical demand curves. Beef, corn, cotton, hay, hogs, pig iron, oats, potatoes, sweet potatoes, sugar, and wheat are on the list of commodities for which we have statements of the "law of demand." Many economists have been skeptical, while others have been enthusiastic, on the significance of such demand curves. In consequence of this divergence of opinion, it may be well to consider some of the theoretical aspects of what the demand curves constructed by our statistical experts may be expected to show. Do they correspond to the demand curves of economic theory? If so, it would seem that they represent something tangible by which our theories may be tested and turned to better account.[2]

Among the statistical studies of demand that have been made, there are cases in which the same commodity has been studied by more than one investigator, and their results indicate varying degrees of elasticity of

2. Among the leading discussions of the subject, the following may be noted:

Lehfeldt, R. A., "The Elasticity of Demand for Wheat," The Economic Journal, June, 1914, pp. 212–217.

Moore, Henry L., Economic Cycles: Their Law and Cause (1914), chaps. 4 and 5; Forecasting the Yield and Price of Cotton (1917), chap. 5; "Empirical Laws of Demand and Supply and the Flexibility of Prices," Political Science Quarterly, December, 1919; "Elasticity of Demand and Flexibility of Prices," Journal of the American Statistical Association, March, 1922; "Partial Elasticity of Demand," Quarterly Journal of Economics, May, 1926; "A Moving Equilibrium of Demand and Supply," Quarterly Journal of Economics, May, 1925.

Persons, Warren M., "The Correlation of Economic Statistics," Publications of the American Statistical Association, December, 1910, pp. 287–322.

Schultz, Henry, "The Statistical Law of Demand," Journal of Political Economy, October and December, 1925.

Working, Holbrook, "The Statistical Determination of Demand Curves," Quarterly Journal of Economics, August, 1925.

In this list no attempt is made to include the many studies of demand of specific articles. A bibliography of the latter is given by Holbrook Working, Quarterly Journal of Economics, August, 1925, pp. 539–543.

demand. But despite this, in all but one of the cases the demand curves have been negatively inclined — they have been in accord with Marshall's "one general *law of demand.*"[3]

In the case of pig iron, however, Professor H. L. Moore finds a "law of demand" which is not in accord with Marshall's universal rule. He finds that the greater the quantity of pig iron sold, the higher will be the prices.[4] If this is the nature of the statistical demand curve for pig iron, surely statistical demand curves must be of a very different sort from the demand curves of traditional economic theory!

Professor Moore holds that the statistical "law of demand" at which he arrives is a *dynamic* law, while that of theory is a *static* law. He says in part: "The doctrine of the uniformity of the demand function is an idol of the static state — the method of *cæteris paribus* — which has stood in the way of the successful treatment of dynamic problems." If it be true that statistical demand curves and the demand curves of theory differ so utterly from each other, of what value is statistical analysis to the theorist — of what value is economic theory to the statistical analyst? It would seem that so far as the study of demand is concerned, the statistical analyst and the economic theorist are on paths so divergent as to be wholly out of touch with each other. Before we accede to such a discouraging thought, let us examine a little more closely the nature of statistical demand curves as they may be viewed in the light of economic theory.

3. "There is then one general *law of demand:* — The greater the amount to be sold, the smaller must be the price at which it is offered in order to find purchasers; or, in other words, the amount demanded increases with a fall in price and diminishes with a rise in price." Alfred Marshall, Principles of Economics (eighth edition), p. 99.

4. Henry Ludwell Moore, Economic Cycles: Their Law and Cause (1914), p. 114.

Let us first consider in what way statistical demand curves are constructed. While both the nature of the data used and the technique of analysis vary, the basic data consist of corresponding prices and quantities. That is, if a given quantity refers to the amount of a commodity sold, produced, or consumed in the year 1910, the corresponding price is the price which is taken to be typical for the year 1910. These corresponding quantities and prices may be for a period of a month, a year, or any other length of time which is feasible; and, as has already been indicated, the quantities may refer to amounts produced, sold, or consumed. The technique of analysis consists of such operations as fitting the demand curve, and adjusting the original data to remove, in so far as is possible, the effect of disturbing influences. For a preliminary understanding of the way in which curves are constructed, we need not be concerned with the differences in technique; but whether the quantities used are the amounts produced, sold, or consumed is a matter of greater significance, which must be kept in mind.

For the present, let us confine our attention to the type of study which uses for its data the quantities which have been sold in the market. In general, the method of constructing demand curves of this sort is to take corresponding prices and quantities, plot them, and draw a curve which will fit as nearly as possible all the plotted points. Suppose, for example, we wish to determine the demand curve for beef. First, we find out how many pounds of beef were sold in a given month and what was the average price. We do the same for all the other months of the period over which our study is to extend, and plot our data with quantities as abscissas and corresponding prices as ordinates. Next we draw a curve to fit the points. This is our demand curve.

In the actual construction of demand curves, certain refinements necessary in order to get satisfactory results are introduced.[5] The purpose of these is to correct the data so as to remove the effect of various extraneous and complicating factors. For example, adjustments are usually made for changes in the purchasing power of money, and for changes in population and in consumption habits. Corrections may be made directly by such means as dividing all original price data by "an index of the general level of prices." They may be made indirectly by correction for trends of the two time series of prices and of quantities. Whatever the corrections and refinements, however, the essence of the method is that certain prices are taken as representing the prices at which certain quantities of the product in question were sold.

With this in mind, we may now turn to the theory of the demand-and-supply curve analysis of market prices. The conventional theory runs in terms substantially as follows.[6] At any given time all individuals within the scope of the market may be considered as being within two groups — potential buyers and potential sellers.[7] The higher the price, the more the sellers will be ready to sell and the less the buyers will be willing to take. We may assume a demand schedule of the potential buyers and a supply schedule of the potential sellers which express the amounts that these groups are ready to buy

5. Instead of using actual prices and quantities, percentage changes or link relatives of prices and quantities may be used. In note 2 on page 213 will be found references to various discussions of the details of statistical procedure used in the consideration of demand curves and also of the theory of statistical analysis of demand curves.

6. Alfred Marshall, Principles, book v, chap. 2. F. W. Taussig, Principles, chap. 10; "Is Market Price Determinate?" Quarterly Journal of Economics, May, 1921, p. 204.

7. This does not mean that the same individual may not be in both groups. He may be a potential seller at any price above a certain level and a potential buyer at any price below.

and sell at different prices. From these schedules supply and demand curves may be made. Thus we have our supply and demand curves showing the market situation at any given time, and the price which results from this situation will be represented by the height of the point where the curves intersect.

This, however, represents the situation as it obtains at any given moment only. It may change; indeed, it is almost certain to change. The supply and demand curves which accurately represent the market situation of to-day will not represent that of a week hence. The curves which represent the average or aggregate of conditions this month will not hold true for the corresponding month of next year. In the case of the wheat market, for example, the effect of news that wheat which is growing in Kansas has been damaged by rust will cause a shift in both demand and supply schedules of the traders in the grain markets. The same amount of wheat, or a greater, will command a higher price than would have been the case if the news had failed to reach the traders. Since much of the buying and selling is speculative, changes in the market price itself may result in shifts of the demand and supply schedules.

If, then, our market demand and supply curves are to indicate conditions which extend over a period of time, we must represent them as shifting.[8] A diagram such as the following, Figure I, may be used to indicate them.

8. Compare Taussig, "Is Market Price Determinate?" Quarterly Journal of Economics, May, 1921, p. 204. This article illustrates a somewhat different way of representing market conditions. It represents the curves as being of uncertain conformation rather than as shifting.

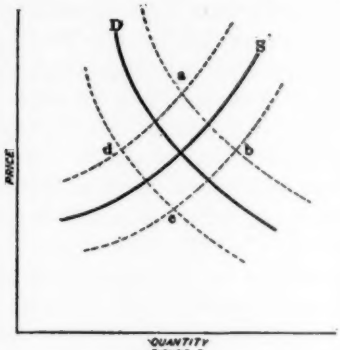


FIGURE I

The demand and supply curves may meet at any point within the area *a*, *b*, *c*, *d*, and over a period of time points of equilibrium will occur at many different places within it.

But what of statistical demand curves in the light of this analysis? If we construct a statistical demand curve from data of quantities sold and corresponding prices, our original data consist, in effect, of observations of points at which the demand and supply curves have met. Altho we may wish to reduce our data to static conditions, we must remember that they originate in the market itself. The market is dynamic and our data extend over a period of time; consequently our data are of changing conditions and must be considered as the result of shifting demand and supply schedules.

Let us assume that conditions are such as those illustrated in Figure II, the demand curve shifting from D1 to D2, and the supply curve shifting in similar manner from S1 to S2. It is to be noted that the chart shows approximately equal shifting of the demand and supply curves.

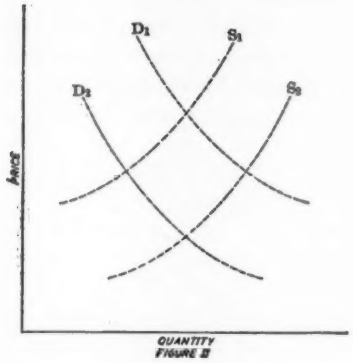


FIGURE II

Under such conditions there will result a series of prices which may be graphically represented by Figure III. It is from data such as those represented by the dots that we are to construct a demand curve, but evidently no satisfactory fit can be obtained. A line of one slope will give substantially as good a fit as will a line of any other slope.

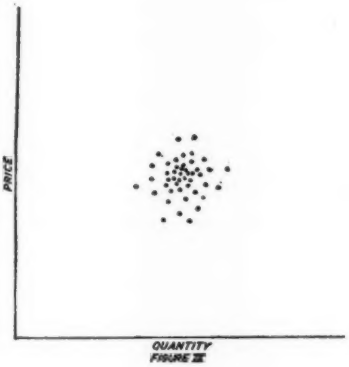


FIGURE III

But what happens if we alter our assumptions as to the relative shifting of the demand and supply curves? Suppose the supply curve shifts in some such manner as is indicated by Figure IV, that is, so that the shifting of the supply curve is greater than the shifting of the de-

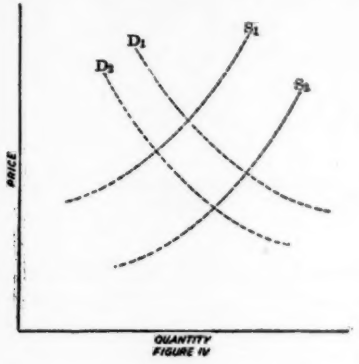


FIGURE IV

mand curve. We shall then obtain a very different set of observations — a set which may be represented by the dots of Figure V. To these points we may fit a curve

FIGURE V

which will have the elasticity of the demand curve that we originally assumed, and whose position will approximate the central position about which the demand curve shifted. We may consider this to be a sort of typical demand curve, and from it we may determine the elasticity of demand.

If, on the other hand, the demand schedules of buyers fluctuate more than do the supply schedules of sellers, we shall obtain a different result. This situation is illustrated by Figure VI. The resulting array of prices and quantities is of a very different sort from the previous case, and its nature is indicated by Figure VII. A line drawn so as most nearly to fit these points will approximate a supply curve instead of a demand curve.

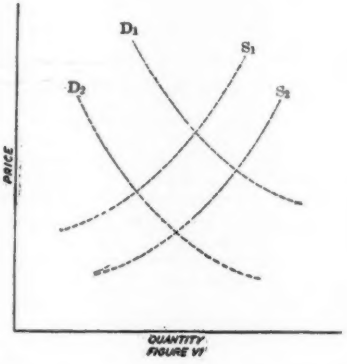


FIGURE VI

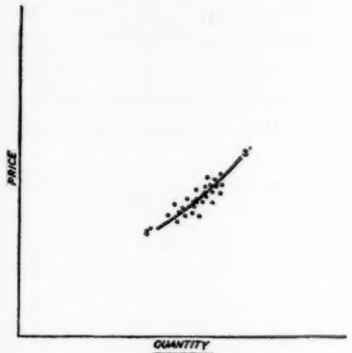


FIGURE VII

If this analysis is in accord with the facts, is it not evident that Professor Moore's "law of demand" for pig iron is in reality a "law of supply" instead? [9] The original observations of prices and corresponding quantities are the resultant of both supply and demand. Consequently, they do not necessarily reflect the influence of demand any more than that of supply. The methods used in constructing demand curves (particularly if the quantity data are of quantities sold) may, under some conditions, yield a demand curve, under

9. P. G. Wright (Quarterly Journal of Economics, May, 1915, p. 638) comes to the same conclusion, in a review of Moore's Economic Cycles. Furthermore, his analysis bears some resemblance to that above. However, his specific argument is unfortunate in that he says "the conditions of demand are changed (very probably by improved business conditions) in the direction of a rapid and continuous increase." Apparently Mr. Wright had in mind the results which would be obtained by the use of absolute quantities and prices instead of relative changes in quantities and prices. The trend inherent in the production figures due to a continuous increase in demand would tend to be eliminated by Moore's use of *relative* changes in quantities unless there were a distinctly progressive increase. Mr. Wright's contention that the peculiar result was due to a shifting of the demand curve is quite correct. Mr. Wright, to whom the present paper has been submitted, now concurs that the result is due to a shifting back and forth rather than to a continuous shift of the demand curve to the right.

others, a supply curve, and, under still different conditions, no satisfactory result may be obtained.

In the case of agricultural commodities, where production for any given year is largely influenced by weather conditions, and where farmers sell practically their entire crop regardless of price, there is likely to be a much greater shifting of the supply schedules of sellers than of the demand schedules of buyers. This is particularly true of perishable commodities, which cannot be withheld from the market without spoilage, and in case the farmers themselves can under no conditions use more than a very small proportion of their entire production. Such a condition results in the supply curve shifting within very wide limits. The demand curve, on the other hand, may shift but little. The quantities which are consumed may be dependent almost entirely upon price, so that the only way to have a much larger amount taken off the market is to reduce the price, and any considerable curtailment of supply is sure to result in a higher price.

With other commodities, the situation may be entirely different. Where a manufacturer has complete control over the supply of the article which he produces, the price at which he sells may be quite definitely fixed, and the amount of his production will vary, depending upon how large an amount of the article is bought at the fixed price. The extent to which there is a similar tendency to adjust sales to the shifts of demand varies with different commodities, depending upon how large overhead costs are and upon the extent to which trade agreements or other means are used to limit competition between different manufacturers. In general, however, there is a marked tendency for the prices of manufactured articles to conform to their expenses of production, the amount of the articles sold varying with the inten-

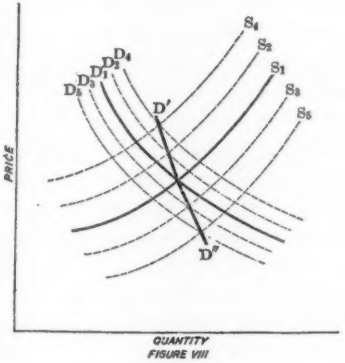
sity of demand at that price which equals the expenses of production. Under such conditions, the supply curve does not shift greatly, but rather approximates an expenses-of-production curve, which does not vary much from month to month or from year to year. If this condition is combined with a fluctuating demand for the product, we shall have a situation such as that shown in Figures VI and VII, where the demand curves shift widely and the supply curves only a little.

From this, it would seem that, whether we obtain a demand curve or a supply curve, by fitting a curve to a series of points which represent the quantities of an article sold at various prices, depends upon the fundamental nature of the supply and demand conditions. It implies the need of some term in addition to that of elasticity in order to describe the nature of supply and demand. The term "variability" may be used for this purpose. For example, the demand for an article may be said to be "elastic" if, at a given time, a small reduction in price would result in a much greater quantity being sold, while it may be said to be "variable" if the demand curve shows a tendency to shift markedly. To be called variable, the demand curve should have the tendency to shift back and forth, and not merely to shift gradually and consistently to the right or left because of changes of population or consuming habits.

Whether a demand or a supply curve is obtained may also be affected by the nature of the corrections applied to the original data. The corrections may be such as to reduce the effect of the shifting of the demand schedules without reducing the effect of the shifting of the supply schedules. In such a case the curve obtained will approximate a demand curve, even tho the original demand schedules fluctuated fully as much as did the supply schedules.

By intelligently applying proper refinements, and making corrections to eliminate separately those factors which cause demand curves to shift and those factors which cause supply curves to shift, it may be possible even to obtain both a demand curve and a supply curve for the same product and from the same original data. Certainly it may be possible, in many cases where satisfactory demand curves have not been obtained, to find instead the supply curves of the articles in question. The supply curve obtained by such methods, it is to be noted, would be a market supply curve rather than a normal supply curve.

Thus far it has been assumed that the supply and demand curves shift quite independently and at random; but such need not be the case. It is altogether possible that a shift of the demand curve to the right may, as a rule, be accompanied by a shift of the supply curve to the left, and vice versa. Let us see what result is to be expected under such conditions. If successive positions of the demand curve are represented by the curves D_1, D_2, D_3, D_4, and D_5 of Figure VIII, while the curves S_1,



FISURE VIII

S_2, S_3, S_4, and S_5 represent corresponding positions of the supply curves, then a series of prices will result from the intersection of D_1 with S_1, D_2 with S_2, and so on. If a curve be fitted to these points, it will not conform

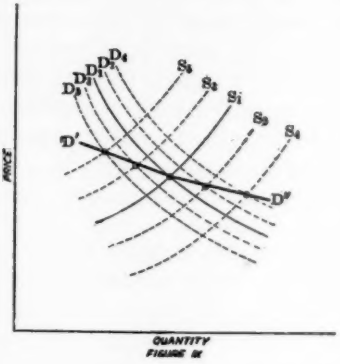


FIGURE IX

to the theoretical demand curve. It will have a smaller elasticity, as is shown by D′ D″ of Figure VIII. If, on the other hand, a shift of the demand curve to the right is accompanied by a shift of the supply curve to the right, we shall obtain a result such as that indicated by D′ D″ in Figure IX. The fitted curve again fails to conform to the theoretical one, but in this case it is more elastic.

Without carrying the illustrations further, it will be apparent that similar reasoning applies to the fitted "supply curve" in case conditions are such that the demand curve shifts more than does the supply curve.

If there is a change in the range through which the supply curve shifts, as might occur through the imposition of a tariff on an imported good, a new fitted curve will result, which will not be a continuation of the former one — this because the fitted curve does not correspond

to the true demand curve. In case, then, of correlated shifts of the demand and supply curves, a fitted curve cannot be considered to be the demand curve for the article. It cannot be used, for example, to estimate what change in price would result from the levying of a tariff upon the commodity.

Perhaps a word of caution is needed here. It does not follow from the foregoing analysis that, when conditions are such that shifts of the supply and demand curves are correlated, an attempt to construct a demand curve will give a result which will be useless. Even tho shifts of the supply and demand curves are correlated, a curve which is fitted to the points of intersection will be useful for purposes of price forecasting, provided no new factors are introduced which did not affect the price during the period of the study. Thus, so long as the shifts of the supply and demand curves remain correlated in the same way, and so long as they shift through approximately the same range, the curve of regression of price upon quantity can be used as a means of estimating price from quantity.

In cases where it is impossible to show that the shifts of the demand and supply curves are not correlated, much confusion would probably be avoided if the fitted curves were not called demand curves (or supply curves), but if, instead, they were called merely lines of regression. Such curves may be useful, but we must be extremely careful in our interpretation of them. We must also make every effort to discover whether the shifts of the supply and demand curves are correlated before interpreting the results of any fitted curve.

In assuming that we are dealing with quantities actually sold in the market, and in disregarding the fact that for many commodities there is a whole series of

markets at various points in the marketing chain, we have simplified our problem. But it has been more than mere simplification, for the interpretation which is to be placed on statistical demand curves depends in large measure upon these matters. Whether the demand curve is a "particular" or a "general" demand curve, depends upon whether or not we use quantities sold. Whether it represents consumer or dealer demand, depends upon the point in the marketing chain to which the quantities sold refer.

Most theorists are acquainted with the concept of the general demand curve as it is presented by Wicksteed and Davenport.[1] Briefly, the idea is that demand should be considered as including not merely the quantities that are bought, but rather all those in existence. The general demand curve, then, includes the possessors of a commodity as having a demand for it at any price below their reservation price, even if they are prospective sellers. Instead of showing the amounts that will be bought at various prices, it shows the marginal money valuation which will be placed upon varying quantities of an existing supply.

Wicksteed even indicates that the supply curve ought not to be considered at all. The following gives an intimation of his viewpoint:

> But what about the "supply curve" that usually figures as a determinant of price, coördinate with the demand curve? I say it boldly and baldly: There is no such thing. When we are speaking of a marketable commodity, what is usually called a supply curve is in reality a demand curve of those who possess the commodity; for it shows the exact place which every successive unit of the commodity holds in their relative scale of estimates. The so-called supply curve, therefore, is simply a part of the total demand curve.[2]

1. P. H. Wicksteed, "The Scope and Method of Political Economy in the Light of the 'Marginal' Theory of Value," Economic Journal, March, 1914, p. 1. See also H. J. Davenport, Economics of Enterprise, pp. 47–51.

2. Wicksteed, ibid., p. 13.

Thus the general demand curve is an expression of the relation between the supply of a commodity and its valuation. In other words, to put it in more familiar terms, it expresses the marginal valuation of different supplies. It is the same sort of thing as a curve of marginal utility, except that it uses monetary valuations instead of abstract "satisfactions" as its ordinate. This raises the question, if, instead of quantities sold, we use quantities produced (total supply) when we construct a statistical demand curve, do we not obtain a general demand curve, and does not this preclude the possibility of obtaining a supply curve? Let us examine the matter a little further.

As it is usually applied, the idea of the general demand curve refers to valuations of an existing stock of durable goods, such as paintings, diamonds, or hats. If it is applied to a stock of non-durable goods, it is of less significance; and in case this stock is replenished periodically, the demand curve must be considered as changing greatly from period to period. For example, in the case of wheat the stock varies greatly, being large just after harvest and gradually dwindling until it becomes very small just before the next harvest. The general demand curve, as applied to an existing stock, would exhibit correspondingly large shifts.

An idea similar to that of the general demand curve is that which is used in regard to *rate* of supply. If, instead of using the rates at which quantities are sold in the market, we use rate of production, which we equate with the unit value of the commodity, we obtain a term which is analogous to the general demand curve. It gives the marginal valuation which would be placed upon various rates of supply, that is, of supplies produced, not of supplies sold. This sort of a demand curve has been called a "general" demand curve, but it is to

be noted that the general demand curve which uses total stocks as its abscissa cannot be placed as coördinate with a supply curve; whereas the demand curve which uses as abscissa total quantities produced can be used in connection with a supply curve of quantities produced.

The use of quantities produced, then, does not give us a general demand curve in the usual sense of the word. Instead, it gives us a demand curve which we may consider as being coördinate with a supply curve, tho we must keep in mind that our supply curve in this case is of supplies produced rather than of supplies sold in the market. The demand curve is of demand for storage and consumption by producers as well as for storage and consumption by buyers. There is no reason why we may not obtain a supply curve instead of a demand curve, even tho we use quantities produced. To do so requires only that shifts in the demand curve be very large relative to those of the supply curve, and that amounts sold differ but little from amounts produced. The scatter of the points will, of course, be greater than if amounts sold had been used.

The question of the difference between consumer and dealer demand presents a problem somewhat analogous to that just discussed. The amount of a commodity sold at one point in the marketing chain may differ from that sold at another in much the same way that the amount produced may differ from the amount sold. This is particularly true if monthly data are used. A case in point would be the demand for eggs. The amount of eggs sold by farmers in the spring of the year is greatly in excess of the amount sold by retail dealers, while in the winter months it is much less. Since differentials between the prices received by farmers and those received by retail dealers remain fairly constant,

very different demand curves would be obtained. The consumers' demand curve would be very much less elastic than that of the dealers who buy from farmers.

Differences between dealer demand and consumer demand are largely dependent upon whether we are considering short or long periods. Over long periods of time, dealer demand tends to conform to consumer demand. This difference, however, is not a thing which depends upon the length of period over which the data extend, but of the length of period to which the individual observations of prices and quantities refer. In the case of eggs, if yearly data were used, the principal difference which would be found between the elasticity of consumer and dealer demands would be due to price differentials alone.

The question whether statistical demand curves are static or dynamic is a perplexing one and rather difficult to deal with. This is largely due to uncertainty as to just what is meant by the terms "static" and "dynamic." Moore holds that his "laws of demand" are dynamic.[3] and that this is an eminently desirable feature. Schultz, while considering it most desirable to obtain both a static and a dynamic law by means of multiple correlation, holds that the statistical devices of relative changes and of trend ratios give a static "law of demand."[4]

Conditions are often defined as being static or dynamic on two different grounds. They may be called static if they refer to a point of time; or else they may be said to be static if all other things are held equal. Statements such as these, however, lack much in clarity and accuracy. How can a statement be made as to prices at

3. Economic Cycles, pp. 64–67, 113.

4. Henry Schultz, "The Statistical Law of Demand," Journal of Political Economy, October and December, 1925. See pp. 498–502 of October issue.

which different quantities of a commodity will sell at a *point* of time? Is it really supposed that *all* other things must be held equal in order to study the demand of the commodity? Rather, the real supposition, tho it may not be accurately expressed, is that the relationships between the various economic factors should be the same as those which exist at a given point of time, or that the relationships between these factors should remain constant.

The data used in a statistical study of demand must, of course, extend over a period of time, but they may in effect conform to conditions at a point of time if trend is removed and if there is no other change in the relationship between quantity and price. Of course, the shifting of the demand and supply curves constitutes a change in the relationship between the quantity and price, but the process of curve-fitting corresponds to that of averaging. Consequently, the fitted curve may be considered to depict the average relationship between quantity and price. This amounts to the same thing as representing the relationship at a point of time which is typical for the period studied. In this sense, then, of relating to a point of time, Moore's "laws of demand" are static instead of dynamic.

Holding "all other things equal," however, is a different matter. Schultz states the difficulty in the following manner:

> In *theory* the law of demand for any one commodity is given only on the assumption that the prices of all other commodities remain constant (the old *ceteris paribus* assumption). This postulate fails in the case of commodities for which substitutes are available. Thus when the price of beef is changed markedly, the prices of such rival commodities as mutton, veal, and pork cannot be supposed to remain constant. Likewise, the price of sugar cannot be increased beyond a certain point without affecting the prices of glucose, corn sugar, and honey.[5]

5. Ibid., pp. 498–499.

Marshall makes similar restrictions as to the need for other things to be held equal, and suggests that in some cases it may be best to "group together commodities as distinct as beef and mutton," [6] in order to obtain a demand curve which will not be too restricted because of other things being equal.

The question arises, however, whether it is desirable to hold all other things equal in any case. Is it not better to have a demand curve for beef which expresses the relation between the price and quantity of beef while the prices of pork, mutton, and veal, vary as they normally do, with different prices of beef? Furthermore, may not this be called a static condition? The point can perhaps be made clearer if we take an extreme example. If we are studying the demand for wheat, it would be almost meaningless to get the demand curve for No. 2 Winter wheat while holding the price of all other grades of wheat constant. Other grades of wheat can be so readily substituted that the demand would be almost completely elastic. The difference between this and holding the prices of pork, mutton, and veal constant, while the price of beef varies, is only one of degree — a difference which depends upon the ease with which substitutes can be used in place of the article whose demand is being studied.

All other things being held equal is not a condition represented by a statistical law of demand or, strictly interpreted, of any useful demand curve theory. Some of the things that are correlated with the price of the commodity in question may be held equal, but it is impossible for all things to be held equal. However, a statistical law of demand represents a condition under which the relationships between factors may be considered to have remained the same, or, to put it more

6. Alfred Marshall, Principles (eighth edition), p. 100 n.

accurately, a condition which is an average of the relationships during the period studied.

In conclusion, then, it is evident that the mere statement that the demand for a commodity has a given elasticity is meaningless. As with the results of all other statistical analysis, statistical demand curves must be interpreted in the light of the nature of the original data and of the methods of analysis used. There are four questions, the answers to which it is particularly important to know. They concern (1) whether the supply or demand curve is more variable, (2) the market to which the price and quantity data refer, (3) the extent to which "other things are held equal," and (4) whether the shifting of the supply and demand curves is correlated or random.

For precision, it is preferable that the data of price and quantity should refer to the same market. Yet this may be out of the question. In a study of the demand for wheat, for example, if we want to obtain a demand curve of the quantity demanded by the entire country, we cannot use prices for all different points and for all different grades. Instead, the price at one market and for one grade may be used as representative, and the demand of the entire country determined for various prices at the one market-place. If the price at any other market or for any other grade were used, the elasticity of demand might be different.

Furthermore, the point in the market chain must be specified and the results interpreted accordingly. As is the case with geographical points, it is preferable that the quantities and prices should refer to the same stage in the marketing process. If this is not the case, the interpretation should be made with the situation in view.

It is to be expected that the methods used in con-

structing statistical demand curves should be such as to give a demand curve which represents a point of time, that is, that trends in both quantities and prices are removed, or else multiple correlation is used to effect the same result. If, in addition to this, other things are held constant, the fact should be noted and the elasticity of demand should be stated as referring to a condition where these other things are held constant.

The matter of correlation between shifts of the demand and supply curves is a more difficult problem to deal with. Every effort should be made to discover whether there is a tendency for the shifting of these to be interdependent. In case it is impossible to determine this, it should be carefully noted that the demand curve which is obtained is quite likely not to hold true for periods other than the one studied, and cannot be treated as corresponding to the demand curve of economic theory.

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THE COPPER-MINING INDUSTRY IN THE UNITED STATES, 1845–1925

SUMMARY

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I. Introduction

Copper was apparently mined by white persons in the United States as early as the first half of the seventeenth century.[1] Not until the middle of the nineteenth century did the copper-mining industry enter upon a period of vigorous existence and growth. In 1845 the first copper produced by the Pittsburg and Boston Mining Company, owners of the Cliff mine on the Keweenaw peninsula, Michigan, came on the market. In the same year, as it happened, the Baltimore and Cuba Smelting and Refining Company began operations

1. James Douglas, "Historical Sketch of Copper Smelting in the United States," in Mineral Industry, iv, 269.

at Baltimore.[2] For 1845 the United States Geological Survey estimates the copper production of the mines of this country at 112 short tons and the contribution of the mines of the Michigan or Lake district at about 13 tons. Fifteen years later, Michigan was producing some 6,000 tons of copper, and the rest of the country about 2,000 tons. In only fifteen of the eighty years since 1845 has production failed to register an increase over that of the preceding year. In 1925 the copper production of the United States, from domestic mines, as Chart I shows, was about 837,500 tons, and in the three war years 1916, 1917, and 1918, production averaged about 950,000 tons a year.[3]

For nearly four decades after 1845, the Lake region was responsible each year for more than one half of the copper output of the country, the proportion in some years being as high as 90 per cent or more. By the late seventies Arizona had begun to yield significant amounts of copper, to be followed soon by Montana. In 1887 Montana passed Michigan; and Montana held first place for just two decades, when she in turn was passed by Arizona. Copper mining has now become largely an industry of the Rocky Mountain States and the Pacific Coast. There is virtually no production east of the 105th meridian, except in Michigan and Tennessee. The growth of output and the shift of the center of gravity of copper mining appear in the following table.

2. Maryland, Its Resources, Industries and Institutions, p. 115.

3. All figures on domestic production, unless otherwise credited, are those of the U. S. Geol. Survey, found in the volumes of Mineral Resources or in "separates" or releases on copper. Tons are short tons, unless otherwise specified.

PRODUCTION OF COPPER IN U. S. IN TONS

State	1845	1865	1885	1905	1915	1925	Per cent in 1925
Alaska.....				2,450	30,347	36,102	4.3
Arizona.....			11,353	117,954	216,234	361,327	43.1
California...		1,800	234	8,349	18,829	23,472	2.8
Michigan ...	13	7,179	36,074	115,144	119,478	69,015	8.2
Montana....			33,899	157,375	134,132	135,302	16.2
Nevada.....					33,879	38,569	4.6
New Mexico.				2,667	31,408	38,224	4.6
Utah.....				29,077	87,589	121,365	14.5
All others ...	99	541	1,378	17,938	17,109	14,059	1.7
Total.....	112	9,520	82,938	450,954	689,005	837,435	100.0

Before production began in Michigan, the output of the country, small as it was, was scattered over a number of regions. Maine, Vermont, Massachusetts, Connecticut, New Jersey, Pennsylvania, and Maryland, at least, had boasted copper mines at one time or another, and with them, smelteries.[4] Vermont was for a while the leading copper-producing state, and the Ely copper mine in Vermont the largest copper mine in the Union. With the small scale of the enterprises of those early days went quite primitive methods of mining and reduction, and a degree of conservatism of operation which comported well with the traditions of the then center of the copper world, Wales and Cornwall. The long and laborious reduction processes that were used, the wastes incident thereto, and the transportation difficulties and costs, brought it about that only relatively rich ores could economically stand reduction. The ores treated in the United States presented no metallurgical problems essentially different from similar ores abroad, and they did not invite to radical metallurgical changes.

4. W. H. Weed, Copper Deposits of the Appalachian States, Bulletin 455, U. S. Geol. Survey, 1911.

From time to time in this review it will be necessary to refer to or describe briefly metallurgical processes, or advances in metallurgical art. It will therefore be advisable to digress for just a moment from the narrative, to advert to the essentials of the "reduction" process whereby copper is "brought up" from the ore stage to the refined metal, more than 99.9 per cent pure.

Most of the copper production of the world comes from deposits in which the ore consists of copper in chemical association with other elements. The native copper ores of Michigan, in which copper is found in metallic form, in the rock, form an outstanding exception to this rule, and commercially the most important. The various sulphides of copper are, taken together, the most common forms in which copper occurs in ores. These include chalcocite, chalcopyrite, bornite, enargite, covellite, and others. In North America, chalcocite is the most important sulphide ore. It furnishes a great part of the production at Butte, Montana, is the chief copper mineral in most or all of the "porphyry" mines of disseminated copper, is found to a notable extent in the high-grade deposits of Arizona, and was found in the massive state (that is, in large lumps unmixed with rock) notably in the Kennecott mines of Alaska. Oxides of copper, and carbonates, have frequently been of importance, especially in certain regions, such as Arizona; these ores include cuprite, the red oxide, and malachite and azurite, the beautiful green and blue carbonates.

Milling (or dressing, or concentration), smelting (preceded often, if not generally, by roasting in the case of sulphides), and refining are the typical stages of copper reduction, or transformation from ore to consumable metal. Since each process results in loss of metal and therefore of value, it is evidently desirable to reduce the number of processes to the lowest possible consistent

with the economics of the given situation. Milling, which is applied, if at all, to those ores which under existing technological and economic conditions are of low grade, consists of stamping and crushing the rock that comes out of the ground, to more or less fine particles, and then effecting as good a separation of the heavier ore from the lighter gangue (the worthless rock) as water and gravity, assisted by jigging, will bring about. The hammer and the pan of the forty-niner constituted his mill, so to speak. Concentrates, middlings, and tailings, or the first and last, are the products of mill-work; the former being the most highly concentrated and most valuable products. Tailings of the final milling go to the dumps, and middlings may be reconcentrated. Oxides and carbonates are not amenable to concentration; in these the ore is lighter in weight than the gangue, instead of being heavier. (Of oil flotation, which has revolutionized concentration, and of hydrometallurgy, something will be said later.)

Except for what goes to the blast furnaces, sulphide ores, whether concentrated or not, typically go to roasters. Here a smoldering fire drives off some of what is considered excess sulphur, and oxidizes the iron. All ore that is subjected to pyrometallurgy goes, and always has gone sooner or later, to the smelting furnace. The products of this furnace are matte and slag. Matte contains principally copper, iron, and sulphur — assaying perhaps 50 per cent copper. Here again gravity comes to the aid of the reduction process. The slag, composed principally of silica, alumina and other worthless materials, is lighter than the matte, which contains all but a very small percentage of the copper, and physical separation occurs in the furnace. The slag is tapped off at one place in the furnace wall, and the matte at another, and the latter

goes to be further refined. Matte goes to the converter, to be blown up to blister copper, so-called because air bubbles escaping from the cooling pigs cause blisters on the surface. Pigs then go to be refined. Refining consists typically of two or more operations, and at present almost invariably ends with electrolytic refining, with copper cathodes as the final product, in addition to the precious metals, if any, that are found in the slime at the bottom of the electrolytic bath. Further furnace work is only melting, to get the copper into the desired shapes — ingots, ingot bars, rods.

There are scores of variations from the various reduction stages just outlined, but for the purposes of this survey the foregoing gives the fundamental steps in and reasons for reduction by pyrometallurgy (*plus* electrolysis). To some of the variations reference will later be made. Native and oxide copper ores are more simply reduced because there is no matte stage. Hydrometallurgy need not concern us at present.

Now if one picks up a textbook on copper metallurgy written as late as the third quarter of the nineteenth century, he will find listed and described a bewildering array of processes of pyrometallurgy — perhaps ten in all — necessary to turn out refined copper. The raw ores or concentrates were roasted — for months — and the calcined (roasted) ores smelted. The matte was allowed to cool and was later broken up, and in turn roasted. Then came another smelting, followed by further fusions and "roastings" of one sort or another. An immense amount of time, labor, and fuel was consumed in these operations; much copper was wasted, and the final product was generally far from being the exquisitely pure metal that is turned out today.

The advent of mining at the Lake at once ushered in

new problems, requiring new solutions. In the first place, Lake copper is native or metallic copper. The reduction processes, as finally worked out, were far simpler and less expensive than the old ones. In the second place, the scale of production, almost from the start, was relatively large in this, the first really extensive copper district in the United States. From that time on, and in growing measure as the trans-Mississippi mines were opened up, nearly every advance of any importance that has taken place in the world's technique of copper metallurgy has been the work of American engineers, working either in this country, or at properties elsewhere in the world that were under American control. The great significance of some of these we shall see later.

II. 1845–1875

If space permitted, it would be interesting to recount some of the episodes of the history of the Lake region in the seventeenth, eighteenth, and early nineteenth centuries.[5] Jesuit missionaries of the seventeenth century found Indians worshiping as divinities, or at least as divine gifts, huge nuggets of copper that were discovered by them from time to time. French and English explorers in the seventeenth and eighteenth centuries reported on the copper resources of the region. It is said that canny Benjamin Franklin, knowing of the existence of the copper deposits, made certain that the copper country was included in the territory of which the United States became possessed by the Treaty of

5. See Foster and Whitney, Report on the Geology and Topography of a Portion of the Lake Superior Land District, in the State of Michigan (Washington, 1850), part I, p. 7; Stevens, Historical Review of the Lake Superior Copper Mining Industry; Neill, Sieur de la Ronde, pp. 189–198; Henry, Travels and Adventures in Canada and the Indian Territories, between the years 1760 and 1766, part II.

Paris in 1783.[6] In 1801, an agent sent out by a Congressional committee, one Robert Cooper, wrote to James Madison: "I may add, Sir, for the future operations of the nation that during the winter I procured satisfactory information that those mines are invaluable to the United States."[7] Other expeditions, under federal authority, followed.[8] In 1841, Dr. Douglass Houghton "was able to lay before the citizens of the States indisputable evidence of the great mineral wealth" of the region.[9] In 1842 the Chippewa Indians made a cession of land which included the whole southern shore of Lake Superior, following which came topographic and linear surveys by state and federal governments.[1] This made possible the opening of the mines, and hundreds of location permits and leases were granted.[2]

As early as 1843, the Boston Advertiser carried correspondence telling of the wealth of the region. The first organized company to locate was the Lake Superior Copper Company, two of whose trustees were the then Secretary of War, David Henshaw, and Lemuel Williams, both of Boston. The first producing organization, the owner of the Cliff mine, was the Pittsburg and Boston Mining Company, formed as an association in 1844, by Pittsburg and Boston men, and later incorporated. Of the Cliff mine, Whitney, writing in the early eighteen-

6. Annual Report of the Commissioner of Mineral Statistics of the State of Michigan (1880), p. 5.

7. The Calumet (Mich.) Public Library contains the report of the Committee and a message from the President thereon.

8. Foster and Whitney, op. cit.

9. Stevens, op. cit.

1. Stat. at Large, vii, 591; Rickard, The Copper Mines of Lake Superior, p. 36.

2. On early Lake history see also Whitney, The Metallic Wealth of the United States (1854); Houghton and Bristol, in Reports of Wm. A. Burt and Bela Hubbard, Esqs., on the Geography, etc., of Lake Superior.

fifties, said: "The discovery and opening of this mine formed an era in the history of Lake Superior, and are also of high interest to the country, as it was the first mine in the United States, those of coal and iron excepted, systematically and extensively wrought, and at the same time with profit." As early as 1849 the company paid its first dividend, from the earnings of the Cliff mine, while many other enterprises operating at the Lake had already gone out of existence.

There are three fairly distinct mining districts at the Lake, on the Keweenaw peninsula of Michigan. Going from northeast to southwest these are the Keweenaw County or Keweenaw Point district, the Portage Lake or Houghton County district, and the Ontonagon district. The Portage Lake district, including as it does the Calumet and Hecla, the Quincy, Tamarack, Osceola, Mohawk and Copper Range mines, and other important producers, past and present, has yielded by far the greatest amount of copper of the three regions; yet it was the last to be developed. Money and labor were expended there, almost from the beginning; but for about ten years, what was spent gave no immediate results. The relatively rich Quincy mine, for example, on which work began in 1846, did not find itself till 1856, when it struck the Pewabic amygdaloid lode.[3] Disappointments, due largely to geological ignorance, led to a distrust of this middle region and to attention being paid chiefly to the territory north and south. Much influence on mining development was exerted by the glamour of the huge masses of copper found in some of the mines of the Ontonagon district, on the one hand, and of the native silver nuggets found in some of the mines on the Point, on the other.

3. Whitney, op. cit., p. 303; Lawton, A Review of Lake Superior Copper Mining, p. 11.

According to Stevens, the seventeen years 1849 to 1865 inclusive, brought total dividend payments from all companies of $5,560,000 — not a fabulous sum, in view of the amount of money that had probably been sunk at the Lake. In 1864 at least eight companies paid dividends, amounting to $1,115,000, or one fifth of the whole sum disbursed during the seventeen years.

It will be of interest here to note the figures of copper production in Michigan and elsewhere in the United States from 1860 to 1865. They are as follows, in tons:

Year	Michigan	Other States	All U. S.
1860	6,035	2,029	8,064
1861	7,519	881	8,400
1862	6,793	3,787	10,580
1863	6,493	3,027	9,520
1864	6,245	2,715	8,960
1865	7,179	2,341	9,520

What was the reason for the steady drop in output at the Lake from 1861 on, in the face of the abnormal demands of the Civil War for copper, and how are increased dividend payments to be explained in the face of this declining production? The drain of men for the army is said to have distinctly affected production, but this is hardly the principal factor. Some of the "old" mines were already beginning to show decreasing returns, both physical and in terms of profits, under the then conditions of cost of production and marketing. The Cliff was hardly holding its own. The output of the Quincy was declining, as was that of others of the best producers. On the other hand, the growing number of dividend payers reflected the increasing number of enterprises that were getting on their feet and passing out of the assessment stage, with work and costs settling down. In other words, for them increasing returns were obtaining, even tho in some cases not for long.

The middle sixties were a turning point for the Lake. Before going further with the story of this region, however, we would do well to see what had been happening elsewhere in the United States.[4] The increases in production outside of Michigan were until the late fifties and early sixties principally the results of the opening of new mines in widely scattered parts of the East, and of the more active working of old deposits. A copper mine at Bristol, Connecticut, and the Ely mine of Vermont had new leases of life. There was a short-lived copper "fever" in New Jersey in 1846–47. In Maryland several mines were opened or reopened. Most important of all were developments in Tennessee and Virginia. In 1843 a Mr. Lemmons (or Semmons?) had discovered red oxide of copper in what is now the Ducktown district in the southeastern corner of Tennessee.[5] Some of the "black oxide" ore for which the district later became famous was discovered in 1847 by a German named Weber. He shipped some of it, assaying 14 to 32 per cent copper, to the Revere Copper Company's smelter near Boston. Development of the district ensued and with it numerous other operations on the southern Appalachians, so that from 1852 to 1856 the South experienced "what the journals of that day called a 'copper mania.'" By 1855, some fourteen mines were at work at Ducktown. In 1854–55 also eight mines were producing on the Carroll vein, or the so-called Great Gossan lead, of southwestern Virginia. Mines were opened, too, in North Carolina, including the Ore Knob, Davidson, and others, and produced during the ante-bellum period.

From the end of the decade of the eighteen-fifties on,

4. Weed, op. cit., passim; Maryland, its Resources, etc., p. 113; Whitney, op. cit., p. 327; Wendt, The Pyrites Deposits of the Alleghenies, in School of Mines Quarterly, vii, 172.

5. Piggot, The Chemistry and Metallurgy of Copper (1858), p. 276. Lemmons did not appreciate the importance of his find.

copper deposits discovered and exploited in the territory which now includes the states of New Mexico, Arizona, and California, accounted for a good part of the increase in the output of the country outside of Michigan. The first production seems to have come from New Mexico, from the mines in the old Santa Rita region, where deposits had been worked at various times in the first half of the century.[6] According to H. H. Bancroft, the Ajo copper mines in Arizona were "worked with some success" in the period between the time of the Gadsden purchase and 1861.[7] Piggot tells of the Arizona mine, in the Gadsden purchase, as having sent to Baltimore and to Swansea some very rich red oxide ore. Santa Rita ores were smelted at home in small adobe furnaces and the bars hauled to Galveston, whence they were shipped, presumably, to Wales. Ajo ores were carted to San Diego or to Yuma, in either case destined for Wales, or perhaps Baltimore or even Boston. In 1862 or 1863 were opened the rich Planet mines on the Bill Williams fork of the Colorado River.[8] The ores ran as high as 60 per cent copper and could stand shipment to San Francisco and to England and still net a profit. In time about fifty mines were opened here and several companies erected smelting works. The latter, and lowered costs of transportation, together with the richness of the ores and the simplicity of their metallurgy, enabled some of the mines to be operated into the eighteen-seventies, in spite of the difficulties of operation and in spite of the lower prices for copper that prevailed after the close of the Civil War.[9] These mines represent

6. Douglas, op. cit., p. 279; Macdonald and Enzian, Prospecting and Mining of Copper Ore at Santa Rita, New Mexico, Bulletin 107, Bureau of Mines, Washington, 1916, p. 7.

7. The History of the Pacific States, xii, 579. See also Joralemon, The Ajo Copper-Mining District, in Bulletin 92, A. I. M. E. (1914), p. 2011.

8. Mineral Resources, 1867, pp. 142, 156.

9. Statistics of Mines and Mining West of the Rocky Mountains, Report for 1872, p. 313; Am. Jour. Min., vi, 19.

the last important discoveries in Arizona until those of the seventies.

California meanwhile was turning out copper as well as gold. In 1862 and the years just following, the chief operations were at Copperopolis, in Calaveras County.[1] Claims were located in a number of counties. One mine, the Union, paid good dividends and was alone responsible for fully half of the ore sent from the state in 1863 and 1864. According to the American Journal of Mining, the predecessor of the Engineering and Mining Journal, the ores exported from San Francisco (whether Californian or other) increased from 3,661 tons in 1862 to 21,477 tons in 1865. It is probable that these ores ranged between 10 and 60 per cent copper, with very little below 15 or 20 per cent.

Let us now return to Michigan. In 1864 the Calumet conglomerate was discovered by Edwin J. Hulbert.[2] The Calumet Mining Company was soon organized to work the lode, and shortly afterwards the Hecla Mining Company was formed to operate on the lands just south of the Calumet. Steady production began in 1866. The yield of the ore was at first about 20 per cent. The companies were under allied control, a group of Boston men headed by Quincy A. Shaw being interested in both properties. The conglomerate rock required different mining and milling methods from those used for the softer amygdaloid rock of other Lake mines, no huge masses were yielded by the lode, there was mismanagement, and there were various difficulties connected with the operations of these properties in the middle of the woods; all of which resulted in a series of assessments. Early in 1867 Alexander Agassiz took the management

1. Mineral Resources, 1867, pp. 139 ff., 143 ff.

2. See, on early Calumet history, Rickard, op. cit.; Letters and Recollections of Alexander Agassiz; Hulbert, Calumet Conglomerate.

out of Hulbert's hands, and he and a man named Davis undertook to straighten matters out. Already in 1866, however, things were being planned on a notable scale — a foretaste of the stupendous scale on which the Calumet and Hecla was later to operate under the large and farsighted management that characterized the long presidency of Agassiz.

Increasing returns were not long delayed. Indeed, once operations were organized, they were inevitable with such a rich mine, even with a decreased copper yield per ton of rock. Assessments were succeeded by dividends, in 1869 for the Hecla, and in 1870 for the Calumet. In 1871 the two companies, together with the neighboring Portland and Scott companies, were combined into the Calumet and Hecla Mining Company.[3] From that time on for about a dozen years, or until Montana and Arizona grew to be important producers, the Calumet dominated not only the Lake region but the whole country in copper output. In the sixteen years from 1871 to 1886, inclusive, the company, with a paid-in capital of $1,200,000, raised its output to 25,000 tons a year, produced all told some 228,000 tons of copper, paid dividends amounting to $27,750,000, equivalent, on the average, to 144.5 per cent a year and to more than six cents per pound of copper produced, and certainly put millions of dollars back into its property, both under ground and in its magnificent surface plant.[4] The average price of Lake copper during this period was not far from 20 cents, at New York.[5] There can be little doubt that the average cost of copper

3. Copper Handbook, x, 523.

4. Production figures from Mines and Min. Stats., Michigan, Report for 1887; dividends in Copper Handbook, ii, 388, 389.

5. Prices, unless otherwise specified, are those found in Mineral Industry, vols. i–xx, and in the Engineering and Mining Journal. This applies to Chart II as well as to the text. Prices for the period through 1898 are for Lake copper; since then, for electrolytic.

produced by the Calumet and Hecla (as an accountant would figure cost) was distinctly under 10 cents, and perhaps nearer 5 than 10 cents a pound. The economic power of such a producer, responsible for fully half of the country's output through 1880, is obvious.

Now with a gradually increased supply of American copper had gone greatly augmented production in and exports from Chile and elsewhere, and at the same time a diminution in demand in certain lines, such as shipbuilding. The inevitable result followed. Copper prices fell, and with them profits of copper mining for most companies, and in a number of cases tonnages of ore production. In 1867, the year that Agassiz took charge of Calumet, the Lake region was calling loudly for tariff protection; surely an ironical coincidence. In December, 1868, Senator Howard of Michigan, pleading for a tariff, told of the hundreds of tenantless houses in the Lake country, and said: "In short, the present state of things, in regard to the copper mines of Lake Superior particularly, threatens immediate and certain ruin to the companies." [6] (It was a Senator from Arizona, which last year produced no less than 43 per cent of the country's output, who in the year of grace 1926, asked for a copper tariff.) Senator Ferry, of Connecticut, a copper-fabricating state, opposing the bill in 1868, told of petitions from smelteries, shipbuilders, ship-owners, and fabricators, against a tariff.[7] The smelters opposed because much of their business consisted of the treatment of foreign ores, which were doubly desirable because they made a good smelting mixture with some of the domestic ores. Shipbuilders and ship-owners naturally did not want the cost of such an important material as copper increased; and ship-owners who had been enjoy-

6. Cong. Globe, 3rd sess., 40th Cong., p. 159.
7. Ibid., p. 417.

ing a carrying trade in Chilean ores had a further ground for complaint. Copper mines which were dependent in part on the existence of the smelters as an outlet for their ores feared any move which threatened the life of the smelters. Nevertheless protection was granted early in 1869, the bill having to be passed over the veto of President Johnson. The act put a duty of three cents on each pound of fine copper contained in imported copper ores; four cents a pound on the fine copper content of partially refined metal; and five cents a pound on plates, bars, ingots, and pigs.[8] The act seemingly had some of the expected evil effects, and, altho for a few years it helped to keep domestic copper prices up, certainly in the long run it did little good. The tariff, while lowered in the eighteen-eighties, was not finally removed until the nineties. Its original imposition could hardly have been more foolishly timed, as events turned out.

During the seventies, production in the United States outside of Michigan increased but little, so that American copper and Lake copper were almost synonymous, and even among the producers at the Lake, Calumet was almost a Gulliver among Lilliputians. Furthermore, Lake copper was superior as a metal product to other then existing brands. Some of the Lake mines took advantage of these facts and of the tariff of 1869 to combine in a loose selling agreement and pool their output, designating the Calumet and Hecla as selling agent for the pool.[9] More will be said later about this pool. Suffice it to mention it here and to note that through it came an accretion of economic power to the Calumet and Hecla.

8. 16 Stat. at Large, 274.
9. See, e. g., Min. Res., 1883, p. 234.

III. 1875–1895

During this same decade of the seventies copper deposits were discovered in Arizona and Montana which were in the eighties to change the whole face of things. We have seen that western Arizona was responsible for some copper production in the sixties and early seventies. In the year 1871 some prospectors from New Mexico made the first copper discoveries in what was later to be known as the Clifton-Morenci district, a large producer in Graham County, in eastern Arizona.[1] At the time the camp was seven hundred miles from the nearest railroad station; but within two years Lezinsky Brothers, who had taken an interest in the Longfellow mine, had erected the first crude adobe furnace to treat their ores. The district has been a steady producer ever since, tho dividends seem not to have been forthcoming for some time. It has been practically a one-mine or two-mine camp, dominated by the Arizona Copper Company during most of the past half-century.

In 1874 came discoveries at what is now Globe, in Gila County, Arizona, and the Globe claim, now part of the Old Dominion mine, was located, along with others, including some silver territory.[2] Copper was neglected at first. Ransome says that the first notices of copper prospecting are in the Arizona Silver Belt newspaper of July 11, 1878, and refer to abundant ore. Still it was only in 1881 and thereafter that the deposit was given serious attention. In that year, the Southern Pacific, which had been building westward, was completed in the Territory of Arizona. Globe was still one hundred and forty miles away from the railroad; but it began to grow, its most rapid development coming after the

1. Hamilton, The Resources of Arizona (2nd ed.), p. 103.
2. Ransome, Description of the Globe Quadrangle. Globe Folio, Geologic Atlas of the U. S. (U. S. G. S.), p. 13.

Southern Pacific had been connected with it by rail in 1898. The richness of its oxide and carbonate ores and their simple metallurgy enabled the Globe district to become a notable producer even in the eighties. It has been one of the four or five great copper camps of Arizona.

Meanwhile, at Bisbee, a few miles from the southern boundary of Arizona, the Copper Queen ore body had been discovered in 1877.[3] Miners had worked on the Queen hill first on a small deposit of lead ore, a deposit later known as the Southwestern mine of the Copper Queen. Nothing but prospecting work was done on the copper ore body till 1880, in which year the Copper Queen Mining Company began operations and soon blew in its first copper furnace. Within four years this company had produced 34,500,000 pounds of copper, from ore running over 20 per cent copper, and had paid $1,350,000 in dividends. Various other claims were located near the Queen, including those of the Neptune Mining Company and the Atlanta Mining Company. In 1881 the Atlanta claim was bought by Messrs. James and Dodge, then the senior members of the firm of Phelps, Dodge and Company. In view of the later prominence of this firm in the copper industry, this was an event of no little importance. The Atlanta sought in vain for three years for an ore body, and in 1884 the Queen had exhausted its original ore body and was also searching fruitlessly for another, when almost at the same time, just as each company was about to give up, both encountered a new rich deposit. With the choice

3. Hamilton, op. cit., p. 85. See also James Douglas, The Copper Queen Mine, Arizona, in Trans. A. I. M. E., xxix, 511; The Copper Queen Mines and Works, in Trans. Instn. Min. and Met., 1912–13, p. 535. Also Description of Property of the Copper Queen Mining Company, issued by the Company, 1882. (New York Public Library.) Also, Eng. Min. Jour., lv, 109.

of fighting each other or combining, they wisely chose the latter. In 1885, therefore, the Copper Queen Consolidated Mining Company came into existence. From then on, Bisbee has been one of the great copper camps, and the Copper Queen one of the really great copper mines of the world.

In the late seventies and early eighties Montana also came into prominence as a copper-producing region. Butte had been a gold placer camp, dating back to 1864.[4] A limited supply of water (essential for placer work) and the appearance "of many outcrops of mineral veins which seamed the surface of the hills" had led to deep mining there and early locations were made on silver and copper lodes. As early as 1866–67 an experimental furnace was erected near Butte to smelt ores, especially from the Parrot lode.[5] Following unsuccessful attempts to reduce these ores, coupled with the exhaustion of the richer placers, the camp became nearly deserted. Interest in Butte was again aroused in 1875 by some rich silver discoveries. Ore was shipped to smelters at Salt Lake City, and Walker Brothers, of that city, purchased the Alice mine, north of Butte. In Butte proper some silver mines were opened, including the Anaconda. It happened that just at this time, 1879, the Colorado Smelting and Mining Company erected at Butte a plant to make copper matte and regulus — destined to be the first successful copper smelter there.[6] The existence of this smelter doubtless gave encouragement to copper mining. Everything hitherto, however, was to be overshadowed by another event. Messrs. Haggin, Tevis, and Hearst had taken an option on the

4. Butte Folio, Geological Atlas of the U. S. (U. S. G. S.)
5. Min. Res., 1868, Appendix, p. 54. Warren, The Territory of Montana (1876).
6. Butte Folio; Hoffman, Notes on the Metallurgy of Copper in Montana, in Trans. A. I. M. E., 34, 259.

Anaconda mine and had secured Marcus Daly from the Alice mine to manage development at the Anaconda.[7] Before long, copper was struck, extremely rich, but very unwelcome to a silver miner of those days.[8] On Daly's advice the mine was taken over and developed as a copper property. It proved fabulously rich and enormously productive. Meanwhile in 1881 the Utah Northern Railroad — now the Oregon Short Line — had reached Butte from Salt Lake and Butte's future was assured. Other rich mines were opened and added their output to that of the Anaconda. As early as 1887 Anaconda was the chief copper-producing mine of the country and Butte had out-distanced the Lake and was turning out some eighty million pounds of copper a year.

So far as copper mining is concerned, the later eighties witnessed primarily the growth of existing enterprises and districts, with the exception of some operations at Jerome, Arizona, where locations were made as early as 1876.[9] The United Verde Mine, "said to have been worked for silver" from 1880 on, erected a copper furnace in 1883,[1] and became a steady producer in 1888.[2] W. A. Clark of Butte bought the property in 1889. The Verde proved rich not only in copper but, for a copper mine, in gold and silver, and thus a fourth great producing district was added to the three already existing in Arizona. The middle and late eighties, however, witnessed some noteworthy episodes in the commercial, financial and technical fields. Perhaps the one outstanding fact about the period was that it saw a great

7. Private notes; interview (1915) with the late Dr. E. D. Peters.
8. Anaconda's big discoveries of copper came in 1882. Freeman, A Brief History of Butte, p. 17.
9. Lindgren, Ore Deposits of the Jerome and Bradshaw Mountains Quadrangles, Arizona (Bulletin 782, U. S. G. S., 1926), p. 61.
1. Rickard, quoted by Lindgren.
2. Wendt, Copper Ores of the Southwest, p. 69; Copper Handbook, x, 1739; Min. Res., 1887, p. 75.

struggle between the Lake — primarily the Calumet and Hecla — and Montana for supremacy in the American copper world. A few figures will be of interest.

PRODUCTION OF COPPER, IN SHORT TONS

Period	U.S.	Michigan		Montana		Arizona		Mich., Mont., & Ariz.
		Tons	% of U.S.	Tons	% of U.S.	Tons	% of U.S.	% of U.S.
1871–75*	17,136	15,176	88	20	..	189	1	89
1876–80*	24,976	20,967	84	298	1	1,168	5	90
1885	82,938	36,074	43	33,898	41	11,353	14	98
1890	129,882	50,705	39	56,490	44	17,398	13	96

* Annual average.

The country's copper output in 1890 was more than six times its average annual production in the decade of the seventies. The last column shows that all but a small fraction of the production in the second half of the eighties came from the three states mentioned in the table. Tho the percentage of the Lake's contribution to the output of the country declined, production at the Lake was almost steadily increasing. In the three years from 1883 to 1886 the Calumet and Hecla enlarged its output by more than 50 per cent, from 16,563 tons to 25,259 tons;[3] yet 1883 was the year in which Butte really became a formidable competitor of the Lake. In what was said of the events of the seventies, mention was made of a selling pool into which the prominent Lake producers had entered, with Calumet and Hecla as its head and selling agent. This was still in existence in the first half of the eighties, and use was made of it to fight the Western competition. An aggressive selling policy was adopted, prices were slashed at home, and copper

3. Mineral Industry, i, 112.

was dumped abroad.[4] The year 1886 saw perhaps the culmination of this policy, saw Lake copper selling at 10 cents a pound, as against an average price for 1880 of more than 20 cents, and saw a halt to the increased output by the Calumet.[5] Many mines, both in Michigan and in the West, were unable to operate at a profit, others were unwilling to produce at high rates at such price figures. Copper production fell off in both Montana and Arizona in 1886, and in Michigan in 1887; and by this time the Lake pool, under the pressure of Western copper, had become practically powerless. It was no longer in the quasi-monopolistic position it had occupied. The tariff on copper was worse than impotent.

The low prices that had prevailed for copper had encouraged consumption of the metal, and the substitution of copper for iron and steel in power-transmission lines and in other fields. World prices of copper had of course been dominated by American producing and selling policies, and outside of the United States output was tending to decline almost everywhere, except in Spain and Portugal, under the influence of the low prices. Compilations of Henry R. Merton and Company, of London, estimated world production of copper for the four years 1884–87 as follows, in long tons: 1884, 220,000; 1885, 226,000; 1886, 217,000; 1887, 224,000.[6] The gains made by the United States and the Iberian peninsula were practically being offset by losses elsewhere.

Into this situation were injected, during some seventeen or eighteen months from the fall of 1887 to the spring of 1889, the operations of the famous French or Secrétan copper syndicate. Their attempted corner of

4. This is not to say that such western producers as Anaconda were not also aggressive. See Min. Res., 1883, p. 238.
5. See Eng. Min. Jour., xli, 380; xlii, 30, 84, 211; xxxix, 253.
6. Min. Ind., i, 118.

copper was engineered after similar speculations in tin. Some of the operators, it was said, were heavily interested in the Rio Tinto mine of Spain.[7] A large manufacturing corporation, the Société Industrielle et Commerciale des Métaux, itself a large consumer of copper, was used to make contracts with the leading producers of the world for the entire output of the latter for varying periods up to three years.[8] These contracts specified a maximum production, and a delivery price which was either flat (such as £70 per ton) or indeterminate, such as 13 cents a pound plus half of the net profits over that. The Société was said finally to have controlled from 175,000 to 200,000 tons annual production; and this included all the large American mines. Prices were forced up and kept up, so that the average price of Lake copper for 1888 was 16⅝ cents a pound, compared with 11¼ cents for 1887. This naturally stimulated production on all hands, not only outside the syndicate, but inside, since the production maxima fixed in the contracts were above the outputs of 1887. The Merton estimate of world production for 1888 was 258,000 tons, compared with the 224,000 tons shown above for 1887. Profitable mines became more prosperous, mines on the margin of profitableness took a new lease on life, idle mines were reopened; and, in addition, the use of junk copper was augmented.[9] Meanwhile consumption fell off, because of the higher prices. The resultant piling up of copper in the hands of the syndicate led to the collapse of the latter in March, 1889.[1] One of the interesting sequels of the collapse was the coöperation of

7. Ibid., ii, 247.

8. Andrews, "The Late Copper Syndicate," in the Quarterly Journal of Economics, iii, 508; Min. Res., 1887.

9. See Eng. Min. Jour., xlv, 481; xlvi, 509, 529; Ransome, op. cit.; Min. Ind., ii, 236.

1. Min. Res., 1888, p. 46.

the Anaconda and the Calumet in dealing with the French bankers, who wanted to liquidate at once the unsold copper. The American giants informed the bankers that, in the event of such a move, they, the copper companies, would break the market so badly that the bankers would not begin to realize from their sales the nominal value of their assets.[2] The bankers surrendered at discretion. The copper was doled out over a period of three or four years, at a rate which even in the first twelve months did not prevent prices making a substantial recovery.

There were other victories to the credit of the American copper industry during the eighties and early nineties. These were in copper metallurgy. The two innovations of greatest significance were the use of the Bessemer process for copper-converting and the introduction of electrolysis on a commercial scale for the final refining of copper. The former meant an enormous saving in labor, fuel, and time; the latter, a further cheapening of production, a purer copper than had ever been marketed except by the Lake, and a virtually complete recovery of the precious-metal content of the copper bullion. A real revolution in the industry was brought about by these two processes.

Converting consists of bringing forward copper matte to blister copper, which is about 99 per cent pure. Before the use of the bessemerizing process, it took several melting or smelting operations and some roasting besides, to bring matte up to this stage of purity. The Bessemer pneumatic converter made possible the blowing up of matte to blister in a few hours, in one operation (tho at first there were two operations). As time went on, it brought about an increasing measure of

2. Copper Handbook, x, 20. Also private notes from interview with the late Col. Livermore.

continuity of operations, with all the saving involved. It can almost be said that bessemerizing did as much for the copper industry as it did for steel — at least for that major part of the copper industry which was working on sulphide ores.

Butte alone, because of its sulphides, could, among the important producing camps of the eighties, be counted on to make immediate use of the new metallurgy. The Parrot Silver and Copper Company at Butte erected the first regular converters in this country in 1884.[3] Other companies at Butte, perhaps because of their very affluence, did not install converters as rapidly as might have been expected. Not until 1890 did Anaconda install them. Ores meanwhile had been smelted to matte near the mines and the matte treated elsewhere in custom plants, some of it going to Baltimore, much of it, especially at first, to Swansea, England. Some of the matte was very rich in precious metals and, according to Dr. James Douglas, "prior to the general adoption of the electrolytic method of refining, argentiferous and auriferous matte was more marketable than (partly refined) metal, except to the bluestone manufacturers, for whose product there was but a limited demand."[4] The electrolytic refining capacity of the country gradually increased, especially after 1890, and with it went an expansion of bessemerizing — a paradoxical reversal of what might have been supposed would be the order of development. What the change was that these two metallurgical factors, working with other causes, wrought, is best shown by the following figures

3. Keller, in Peters, Modern Copper Smelting (7th ed.), p. 528. In the very next year appeared the first quotation in the Engineering and Mining Journal of an electrolytic brand of copper; and it was Parrot copper turned out at the Balbach refinery at Newark, N. J. (Eng. Min. Jour., xxxix, 341.)

4. "Copper Smelting in the United States," in Min. Ind., iv, 284.

of British imports of American copper, in long tons (regulus being matte): [5]

	1883	1884	1885	1892	1893	1894	1897
Ore.....	10,732	31,432	5,970	1,953	1,236	1,478	1,860
Regulus ...	6,435	5,799	29,867	43,892	37,761	4,836	11,863
Unwrought and partly wrought	1,866	3,410	3,259	2,900	17,044	31,724	29,545

The notable years are 1885 and 1893. In the first of these years came a complete reversal in the relative positions of ore and matte exports, the effects of the first steps toward integration of some of the new Montana mines, particularly the Anaconda, whose first smelter (tho without a bessemer converter) began operations in 1884.[6] In 1893 occurred the beginning of a similar change as between matte and more or less refined copper metal. Ore exports had meanwhile become quite unimportant. This was a twofold victory for the American copper industry.[7] The copper industry, tho

5. American figures of exports to Great Britain are useless. The above figures are from Annual Statement of the Trade of the United Kingdom, etc., 1888, 1893, 1898. C5451, 7042, 8896.

6. Mathewson, The Smelters at Anaconda, reprinted in Eng. Min. Jour., lxxxvi, 130.

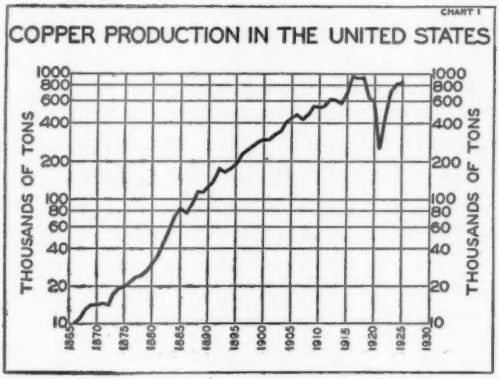
7. American copper ore and matte had gone to Wales for reduction in spite of the costs of transportation and the losses, because the producing mines in this country were such small and irregular producers that the construction of refineries was hardly feasible. (The Lake situation was, of course, in a class by itself because of the large scale of operations and the native copper.) The relatively large scale, for those times, of the Welsh metallurgical operations, the metallurgical advantages inhering in the fact that Wales received so many types of ores and mattes, mixtures of which could be profitably used, and the fact that it cost so much to bring the far western copper to the Atlantic seaboard, especially by land, that an all-sea shipment to Wales sometimes cost less than a shipment to our own seaboard, all favored reduction abroad. The great richness of the early bonanza ores of the far western mines, not only in copper but often in the silver and gold content of the copper ores, helped to postpone the date of domestic treatment of these ores. Of course, the cheapness of British coal, used in reduction of the ores, and the fact that London was the great non-ferrous metal market of the world, and Europe the principal consuming center, were added considerations in keeping the unrefined copper flowing to Wales.

one of the oldest in the world, had not been progressive; and the British smelters, in spite, or because, of their command of a large part of the ores of the world, clung to old metallurgical methods. Their crude methods were wasteful both of copper and of precious-metal content, and were expensive, and their exactions in the form of smelting tolls were serious. The new technology saved on all these grounds, as well as saving the transportation expenses, and permitted a large measure of integration to take place here in America. Equally significant, perhaps, was the fact that with the passing of the leadership of Swansea and Wales in copper reduction went the gradual transfer from London to New York of the position of the world's greatest copper market. This was coincident with the assumption by the United States in 1895, and its retention thereafter, of the position of producer of more than half of the world's copper. The early nineties witnessed another great metallurgical improvement in the introduction of Wilfley ore-dressing tables, which greatly reduced copper milling losses.

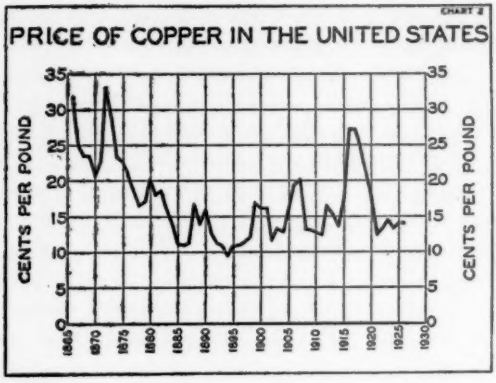
Now in the early nineties everything that helped to reduce costs for the copper industry was welcome enough. In the summer of 1890, the price of Lake copper was above 17 cents a pound. In the fall of that year the "Baring panic" broke in England, followed by unsettled conditions there and elsewhere. British consumption of copper dropped considerably after 1890, and even Germany, in spite of real progress in her electrical industries, apparently increased her consumption but little at just that time. Production, both in the United States and elsewhere, was being enlarged, and the stocks of the French syndicate were being disposed of. The average price of Lake copper, which was 15¾ cents in 1890, was down to 11¼ cents for 1892. In the

United States, to be sure, new or widening fields for the use of copper were opening up at this juncture. For some time copper wires had been replacing iron and steel for telegraphic and telephonic purposes. In 1892, New York and Chicago were connected by telephone over copper wires. In the same year the General Electric Company was formed. In this period also came the initiation of urban electric street railways all over the country. These are but a few examples of the increasing use of copper, a generation ago.

Then broke the panic of 1893, and a long period of depression ensued. In those painful years, when some American industries were fairly prostrated and almost all seriously affected, copper production kept on increasing after 1893, despite the low prices that prevailed. Charts I and II bear witness to this. Much of the credit for this must undoubtedly be given to the technical advances of the late eighties and early nineties, which lowered costs of production and helped to make even low prices profitable for a large part of the copper output.[8]



8. See Min. Ind., iii, 157.



The rise in average price in 1896, in the face of a tremendous relative increase in output, was due largely to the advantage taken by European buyers of the low prices. Exports of copper rose from about 120,000,000 pounds in 1895 to nearly 260,000,000 in 1896 — an even greater increase than that in production.[9] An upward movement in prices thus got under way, which was to reach its climax in 1899, tho prices were to remain high till the second half of 1901.

IV. 1895–1901

The years from 1895 to 1901, inclusive, were in certain respects among the most spectacular that the American copper industry has ever known. In this period the same tendency was manifest in that industry as in other American industries — the tendency of large corporations and groups of capitalists to come into control of more and more units of the industry. The events of the period called forth Thomas W. Lawson's *Frenzied Finance*, a tale concerned primarily with copper and

9. Min. Res. for 1896, part v, p. 197.

copper finance. The greatly enlarged consumption of copper, after the middle nineties, thanks to electrical progress, notable activity in mercantile shipbuilding, the rise of the new German and American navies, wars and increased armaments, and other causes, was well met by increased output under the stimulus of higher prices. How this was brought about, and under what auspices, will now be told.

One of the earliest developments was in California, a state that had been of little relative importance in the copper world since the eighteen-sixties. In 1896 the state was credited with an output of only about 700,000 pounds. In that year an English concern, the Mountain Copper Company, Ltd., opened up a large body of ore in the Iron Mountain mine, in Shasta County.[1] A smelter was at once built. Interest in and production from copper properties elsewhere in the state increased, and by 1900 the output of California had risen to 28,500,000 pounds.[2] Coincidentally there came about some very significant developments in Utah, centered chiefly in the old camp of Bingham, twenty miles from Salt Lake City. The camp had existed since the early sixties.[3] Only in 1896 did production of more than trifling amounts of copper begin. In that year the Highland Boy, originally and even then primarily a gold mine, commenced operations on copper sulphide deposits found on its property.[4] In a short time a Bingham copper boom was on, and, as in California, other parts of the state shared in the new interest.[5] For a while, most of the added output, however, was due to the Highland Boy.

1. Min. Ind., v, 203; vi, 232–235.
2. Ibid., vii, 205; viii, 161; ix, 188; Eng. Min. Jour., lxii, 35; lxvii, passim.
3. Eng. Min. Jour., lxxii, 290; Salt Lake Mining Review, ii, 10.
4. Eng. Min. Jour., lxv, 100; lxxxii, 290. Min. Res., 1915, p. 667.
5. Eng. Min. Jour., lxiv to lxvii, passim.

In 1898 and 1899 occurred two events which in their final results were to affect profoundly the copper output, not only of Bingham, but of the whole world. First, there was formed in England in 1898 the Boston Consolidated Gold and Copper Mining Company, Ltd.,[6] to hold a property on which, even at that time, it claimed to have found 291,000,000 tons of ore, ranging in copper content from 0.75 per cent to 2.5 per cent. The copper was chiefly in the form of sulphides finely disseminated through a porphyritic rock.[7] The Engineering and Mining Journal, commenting editorially on this, said: "It would be impossible to mine or treat ores carrying 2 per cent or less of copper under the existing conditions in Utah. . . . On the company's own showing, therefore, the more ore it has of the kind it claims, the poorer it is."[8] In the second place, representatives of Colonel De Lamar, an entrepreneur-capitalist who had made a success of gold production by the cyanide process from some low-grade deposits at Mercur, in Utah, took ore samples from claims adjoining those of the Boston Consolidated, to test the possibilities of profitable gold production. An adverse decision was reached, but it was also seen that there was a measurable amount of copper present. A young engineer, D. C. Jackling, was sent to look at the property and make a report.[9] He recom-

6. Moody's Manual, 1906, p. 2031.

7. Eng. Min. Jour., lxvii, 614.

8. In fairness to this Journal, it should be noted here that in a "Review of the Copper Industry 1895–1919," which, at the request of the Harvard University Committee on Economic Research, I made in 1920 for the Copper and Brass Research Association, I quoted these words from this editorial, and made some comments thereon. On pages 74 and 75 of "The Story of Copper" by Watson Davis, published in 1924 by The Century Co., occurs a passage in which the quotation from the editorial and the comments thereon correspond to the word and letter with what I had written in 1920. This may be an extraordinary coincidence.

9. Min. and Sci. Press, cxiv, 611 ff.; Eng. Min. Jour., lxviii, 169, 319.

mended the initiation of operations and the erection of a mill with a daily capacity of 2,500 tons of ore. His plans were overridden. In 1903 he returned to Bingham. Options were secured on the property, which were later exercised, and the Utah Copper Company was formed, with holdings of land chiefly on the same hill on which was located the Boston Consolidated. Thus began a new era for copper mining in the United States. These two mines were the first of the group of "porphyry coppers" which were later to contribute huge amounts to the copper output of the world, and whose technological problems were to stimulate engineers to devise and put into practice revolutionary methods of reduction of copper ores. Four of them have been known as Jackling porphyries, because Mr. Jackling has been the guiding spirit in their operations. They have been eminently successful. They have also been known as the Hayden-Stone-Guggenheim coppers, after the dominant financial interests. In 1910 the Utah Copper Company absorbed the Boston Consolidated, the property which had been described as being the poorer, the more ore it possessed. The merger was inevitable, in view of the essentiality and possibility of large-scale mining and reduction operations.

So far, writing of Butte, we have given scant attention to any mines other than the Anaconda. At no time during the nineteenth century, however, did Anaconda occupy in Butte a position quite comparable with that of the Calumet and Hecla at the Lake. In other words, it did not overshadow its neighbors to the extent that Calumet did. Its foremost rival was the Boston and Montana Consolidated Copper and Silver Mining Company. This was a consolidation, effected in 1887, of the Mountain View and Montana Copper companies which later bought other property and developed into an enor-

mously rich and profitable concern.[1] The firm of Lewisohn Brothers, metal brokers, had been the selling agents for the Montana Copper Company's product and as far back as 1879, indeed, had become interested in the properties which had gone to make up that company.[2] On the first board of directors of the Boston and Montana were, among others, Leonard Lewisohn and Joseph W. Clark and Albert S. Bigelow, the last two being associated also on the directorates of the Osceola and Tamarack companies at the Lake.[3] The Boston and Montana was the first of the so-called Bigelow-Lewisohn mines, of which much was to be heard in the following dozen years. In 1888 the Butte and Boston Mining Company was formed to operate a group of claims at Butte, with Messrs. Clark and Bigelow, but seemingly not Mr. Lewisohn, on its first board.[4] Mr. Lewisohn came in time to be on the boards of a number of Lake mines, both Bigelow properties and others; and Lewisohn Brothers were made selling agents for the product of most of these companies.[5] The figures on the following page (in thousands of pounds) show the growth of output of mines under Bigelow-Lewisohn control during the nineties.[6]

This group also initiated operations in Arizona and Tennessee during the nineties. In 1895 the Lewisohns, who had held an option on a majority interest in the Old Dominion mine at Globe, Arizona, purchased it from Baltimore owners.[7] Four years later, they bought the mines of the Pittsburg and Tennessee Copper Com-

1. Eng. Min. Jour., xliv, 50, 65.
2. Ibid., Feb. 12, 1887, Advertisement; ibid., lii, 383.
3. Ibid., xliv, 65.
4. Ibid., xlvi, 224.
5. Ibid., lii, 80, 383.
6. Min. Ind., vols. i, iii, vi, ix. The Michigan mines bracketed in 1897 had been consolidated; not so the two Montana mines.
7. Eng. Min. Jour., lix, 515, 567; lx, 60.

Mine and State	1891	1893	1895	1897	1899
Michigan:					
Tamarack	16,161	15,375	14,840	20,000	17,750
Osceola	6,543	6,879	6,270		
Kearsarge	1,727	1,999	1,946	9,500	10,950
Tamarack, Jr.	....	2,350	2,605		
Montana:					
Boston and Montana	26,508	57,938	60,746	60,000	79,000
Butte and Boston	18,392				
Totals	69,331	84,541	86,407	89,500	107,700

pany and the London and the Burra-Burra mines, all at Ducktown, Tennessee, and organized the Tennessee Copper Company to operate these properties.[8] The interests of this group were thus widespread, and they were to figure in an important way at the very end of the period at present under discussion, in the most spectacular financial episodes that the industry has ever known.

In the early nineties F. Augustus Heinze formed the Montana Ore Purchasing Company to operate mines and reduction works at Butte.[9] It was for a while a moderately large producer. Its importance, however, lies almost wholly in the fact that for the best part of a decade its president, Heinze, was a thorn in the side of the Boston and Montana, the Butte and Boston, and later the Anaconda.[1] This came about through the many suits at law that the company engaged in for possession of veins that its neighbors were working. The company, by purchases and leases of claims, had expanded until it owned or controlled scattered patches in Butte's crazy-quilt of locations, on a number of veins. It then based suits on the "apex" provision of the fed-

8. Ibid., lxvii, 420, 286.

9. Weed, Geology and Ore Deposits of the Butte District, U. S. G. S. Professional Paper 74, p. 21; Copper Handbook, iii, 399.

1. See Eng. Min. Jour., 1897–1906, passim.

eral mining law. This is to the effect that an owner of a mining claim under a federal patent, which includes the apex of a vein of mineral, has a right to follow and work that vein, not only through his own property, but along its "dip" or downward course beyond the sidelines of his claim into adjoining territory. The Butte vein system is very complicated. There was an interminable series of suits and countersuits, with Heinze more than moderately successful in the courts. The litigation came to a close only with the absorption in 1906 of the Montana Ore Purchasing Company by the interests it had been fighting; by which time, as we shall see, the consolidation of Butte mining properties had gone very far.

We turn once more, only partly by way of digression, to Michigan. There occurred here in the late nineties two events of interest. One was the formation of the Baltic, Trimountain and Champion companies, to operate on the Baltic amygdaloid lode on the South Range, in Houghton County. This lode had been opened in 1882, but had later been lost because of an error in drilling.[2] It was rediscovered in 1897, and the Baltic Mining Company organized, followed two years later by the Trimountain Mining Company, the Champion Copper Company, and the Copper Range Company, the latter to own jointly with the St. Mary's Mineral Land Company the shares of the Champion. The Copper Range Railroad Company was also incorporated, to open up the South Range. It was controlled by the Copper Range Company. In 1901, the Copper Range Consolidated Company was organized, acquiring over the next few years virtually all the shares of the Copper Range Company, the Baltic, and the Trimountain. The controlling interests in this develop-

2. Copper Handbook, ii, 124, 125, and elsewhere.

ment were William A. Paine and his associates, and the Stanton-Gay group of New York, who operated other Michigan properties. In 1903 the Michigan Smelting Company was formed to smelt the products of the Copper Range and Stanton mines. Its stock was subscribed for by the Baltic, Champion, Trimountain, Atlantic, Mohawk, and Wolverine mines.[3]

The success of the South Range mines and of some of the Stanton properties, and the relatively high price of copper in the late nineties, caused a revival of interest in the Lake. The second event of note in Michigan, referred to a few paragraphs back, was the entrance of Standard Oil interests into the Michigan situation. The venture was an utter failure, and the episode is worth mentioning simply because of the conjectures it aroused as to whether the Standard group would seek to control one or more of the important Lake companies, and because it was the forerunner of the formation by the same interests of the Amalgamated Copper Company, whose organization was for the copper industry the most important event of the late nineties. The present writer has outlined the history of the Amalgamated in the February, 1916, issue of this Journal, and will refer readers to that rather than repeat much of the story here. It will be seen from the earlier article that within about two years after the Amalgamated was incorporated in April, 1899, it had acquired majority or practically entire control of the stocks of the principal copper-mining companies of Butte,[4] other than Heinze's properties, and that it had organized a selling company to take over the refineries owned by the Lewisohns and the latters' selling agency. It was from the start an im-

3. Copper Handbook, viii, 944. See Eng. Min. Jour., lxxvii, 850, 852.

4. These included the Anaconda, Parrot, Washoe, and the two rich Bigelow-Lewisohn mines, the Boston & Montana and the Butte & Boston.

portant factor in the copper market, and it was said to have as its main object to steady copper prices through its control over a third or more of American copper production. In some quarters it was really hoped that this would be possible, even at the then existing high level of about 16 cents a pound.

The year 1901 witnessed an instructive episode in copper price history. The years 1896–1900, as Charts I and II show, had, in spite of steadily increasing production, seen rising prices for copper, as for many other things. Consumption had fully kept up with enlarged output. The high prices of 1899, 1900, and early 1901 were welcome both to the new mines and to the old ones which had weathered the lean years of the nineties. In 1901 there came a reaction. European buying had in the middle nineties been the dominant factor in pulling copper out of the rut of low prices; now a lessening of copper consumption abroad helped to cause the turn downward. The year 1901 was a crisis year in Germany, related not a little to overexpansion in her electrical industry; and even at that time, Germany was, next to the United States, the largest consumer of copper in the world. Her copper imports from the United States were more than 66,000 tons in 1900; in 1901 they dropped to 43,000 tons.[5] Similar situations obtained for England and France. During much of 1901 the United Metals Selling Company, the Amalgamated's selling subsidiary, doggedly pursued its policy of maintaining copper prices, in spite of decreased consumption, holding back sales and accumulating copper, even in the face of underselling by competitors. Toward the end of the year it gave way, slashed prices, and began to get rid of the load of copper it had been carrying. Within two months of 17-cent quotations by the company, copper

5. Statistisches Jahrbuch, 1903.

was selling — in January, 1902 — at around 11 cents, the lowest price in four years.

Now this period of high prices and the "umbrella holding" by United Metals had been a godsend for some of the competitors of Amalgamated. Not only had it permitted the payment of good dividends, but it had permitted also, from the large profits that were made from large production sold at high prices, good reinvestment in mining properties. This was an especial blessing for mines on the margin of profitableness as well as for new mines. Partly as a result of this, steady increases in output for the country took place in 1902, 1903, and 1904, in spite of prices which were well below the average of 1897–1901. It was freely rumored, to be sure, that the greatly increased production of the Anaconda in 1902 was to some extent due to a desire of the Amalgamated to punish its rivals for the underselling in 1901, by steadying the market at a *low* figure instead of a high one![6]

In the three high-price years 1899–1901, interesting developments had been going on at Bisbee, which since 1885 had been virtually a one-mine camp, dominated by the Copper Queen.[7] In 1899 Captain James Hoatson, of Calumet, Michigan, and a few other Michigan men began work at the Irish Mag mine near Bisbee and formed the Lake Superior and Western Development Company.[8] After two years of preliminary operations, with results so favorable that a "Bisbee fever" at the Lake was the consequence, the Calumet and Arizona Mining Company was organized. In 1902, when its

6. See, e. g., Min. Ind., xi, 184.

7. The Holbrook and Cave Company had been a significant producer for a while, but this was controlled by interests allied to those in the Queen.

8. See the interesting account by Dr. Douglas of the purchase of the Irish Mag mine in Trans., Instn. Min. and Met., 1912–13, p. 546.

first copper came on the market, it sold some 1,200,000 pounds, raising this the very next year to over 25,000,000 pounds.[9] The same interests formed other companies also, control of which was turned over to the Calumet and Arizona in 1911.[1] The only other important company operating at Bisbee, other than the Queen and the Calumet and Arizona, has been the Shattuck and Arizona Copper Company, which was organized in 1904 and began shipments in 1906.[2] It is worthy of note that there has been thoro friendliness between the producers at Bisbee, in marked contrast to the conditions at Butte to which reference has been made. A most practical evidence of this has been in the form of the agreements to disregard the apex law and to let "the side and end line carried down vertically define the ownership of the minerals in depth." Free access to each other's mines and to each other's geological information has also been granted. This has been no small factor in the rapid growth in output of the Bisbee camp.

V. The Decade Before the War.

So much for the summary of the outstanding episodes of the eventful years 1895–1901. The years immediately following the Bisbee developments witnessed only two other developments of importance in copper mining in this country. One was the opening in 1905 of low-grade deposits at Ely, Nevada, similar to those at Bingham, and destined to be exploited in like fashion to

9. Copper Handbook, x, 521.

1. Eng. Min. Jour., lxxx, 1037; Copper Handbook, viii, 1920; Application (A-4700) of the Calumet and Arizona to list stock on the New York Stock Exchange. In 1916, the Calumet and Arizona took over all the assets of the Superior and Pittsburg Copper Company, which in 1906 had consolidated the allied properties, and of which Calumet and Arizona acquired 93 per cent of the stock in 1911.

2. N Y. Stock Exch. listing application A-4537.

those in the Utah camp,[3] and by the same interests. The other was the formation in 1905 of the North Butte Mining Company, to work claims at the northern end of the Butte camp.[4] Captain Hoatson and Mr. Thomas F. Cole, who had also been one of the organizers of the Calumet and Arizona, organized this new company and bought a large number of claims and fractions. A bonanza deposit was soon struck, and North Butte at once took its place as an important producer. This brought Mr. Cole (who, incidentally was president of the Oliver Mining Company, the great ore subsidiary of the United States Steel Corporation) into the Butte situation, and in 1906 he and John D. Ryan, then General Manager of the Amalgamated, carried on the negotiations which ended the impossible Heinze-Amalgamated situation at Butte. This was effected by the transfer of Heinze's Butte copper properties to the Butte Coalition Mining Company, officered by Messrs. Cole and Ryan and others.[5]

Before going further with the narrative, let us review the domestic production figures for the first decade of the twentieth century. They are as follows (in thousands of tons):

State	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910
Alaska.....	...	...	1	1	2	4	3	2	2	2
Arizona.....	65	60	74	96	113	131	128	145	146	149
California ...	17	13	9	14	8	14	17	20	27	23
Michigan....	78	85	96	104	115	115	110	111	114	111
Montana....	115	145	136	149	157	147	112	126	157	142
Nevada.....	...	...	...	...	...	1	1	6	27	32
Utah.....	10	12	19	24	27	25	33	36	51	63
Others.....	16	15	14	18	22	22	31	25	23	18
Total	301	330	349	406	444	459	435	471	547	540

3. Min. Ind., xiv, 130.
4. Moody's Manual, 1906, p. 2066; Eng. Min. Jour., lxxix, 784.
5. Moody's Manual, 1906, p. 2032; Eng. Min. Jour., lxxxi, 391, 445.

The notable growths in production in Utah after 1906 and in Nevada after 1907 are to be ascribed almost entirely to the "porphyry" mines in these states. In Montana the fluctuations are in all probability primarily the fluctuations in the total output controlled by the Amalgamated, tho there are no figures available which permit one to trace movements in production by mines. It is noteworthy that in the panic year of 1907 the only serious decline in output in any important state occurred in Montana. Amalgamated in that year did not attempt to "hold the umbrella" to anything like the extent that it did in 1901, if at all, and apparently led all other companies in curtailing output after and even before prices broke. (Of price movements a little more will be said later.)

In Michigan the increased output was widely distributed. In the nine years 1901 to 1910, the copper production of the state rose by about 33,000 tons. Of this the three Copper Range mines accounted for about 20,000 tons. The rest was contributed by four mines in Keweenaw County, the Mohawk, Wolverine, Ahmeek, and Allouez. The first two were Stanton mines, and all but the Mohawk were properties that had previously been worked and been abandoned.[6] Among the other mines of the district, including the Calumet, increases and decreases roughly balanced, and none of them was of particular significance.

In the case of Arizona, we note a doubling of production in the five years 1901–06.[7] Of this gain of some 65,000 tons, Bisbee accounted for 40,000, — 23,000 due to the Calumet and Arizona group and 16,000 to the Copper Queen, helped by purchases of additional mining

6. Copper Handbook, ii, 105, 106, 203, 284.

7. For the production statistics in this paragraph, see Min. Ind., xii, 76, and xvi, 269. See also Douglas, J., in Trans., Inst. Min. and Met., 1912–13, p. 545.

claims and made possible by the erection of a greatly enlarged smelter at Douglas — the remainder coming from the Shattuck Arizona. The rest of the gain in Arizona was scattered. The Globe district was responsible for more than 7,500 tons of the increase, of which three fourths came from the neighboring mines, the Old Dominion and the United Globe, consolidated in the Old Dominion Company, under Phelps, Dodge control.[8] The old Clifton district showed a gain of about 10,000 tons, more than half of which came from the Shannon mine. This mine had begun developments in 1900 and had blown in its smelter in 1902.[9] Over the last four years of the decade the gain in Arizona copper output was relatively small, tho meanwhile it had attained the position of the leading copper-producing state of the Union. No new camps made important contributions, tho in two camps developments were taking place which were to result in a few years in the creation of three huge "porphyry" mines.

The history of the decade must not be left without adverting to the price movements of the years after 1904. An upward swing from the 12½-cent level began in the latter part of that year, and culminated only in March, 1907, when copper got above 26 cents a pound, the highest price since 1873. Seven months later the price was again under 14 cents. A great increase in the consumptive demand for copper, in this country and elsewhere, reflecting in the copper industry the somewhat feverish condition of industry generally in the years 1905–07, brought about the enormous rise in prices, tho charges of manipulation of prices and of

8. The United Globe was bought by Dr. Douglas in the nineties for the Phelps, Dodge interests. (Eng. Min. Jour., cii, 706.) In 1902 control of the Old Dominion was taken from the Bigelow-Lewisohn group. (Eng. Min. Jour., lxxiii, 494.)

9. Copper Handbook, x, 1549; Lindgren, The Copper Deposits of the Clifton-Morenci District, pp. 46, 47.

"visible supplies" were common enough. Increased production was, of course, encouraged and was forthcoming, as the table shows; tho much of what did take place might have occurred even without such a rise in price as it accompanied. The greater part of the increment of production in those thirty months from the fall of 1904 to the spring of 1907 came from a more intensive working of established mines, not from new properties. In 1906, complaints were general of difficulties encountered from shortages of labor, fuel, and transportation facilities, which kept output down. After the collapse of prices in 1907, there was substantial curtailment in some districts, especially at Butte, where, because of a particular labor situation, unit operating costs tended to mount more rapidly than at some other camps.

The fact that copper prices were in the doldrums practically through 1911 did not prevent either substantial increase in output of copper from existing mines — indeed, the increase of over 100,000 tons in domestic production certainly helped to keep prices depressed — or developments of new properties, and especially of four "porphyries" in the Southwest. The Miami Copper Company was organized in 1907 by Lewisohn interests, to operate on a deposit at Miami, Arizona, eight or ten miles from Globe.[1] At Ray, Arizona, twenty odd miles southwest of Globe, the Ray Consolidated Company, also organized in 1907, developed a large deposit. This company was controlled by the same interests that controlled the Utah and Nevada,[2] and so was the Chino Copper Company, formed in 1909 to operate, by typical porphyry-mine methods, the old Santa Rita mine in New Mexico.[3] The fourth of the big porphyries of the Southwest was the Inspiration Consolidated Copper Company, a neighbor of the Miami, which merged

1. Copper Handbook, x, 1158. 2. Ibid., p. 1459.
3. Ibid., pp. 604, 605.

in 1912 the Inspiration Copper Company, formed in 1908, and the Live Oak Development Company.[4] In the Inspiration, Messrs. Cole and Ryan were interested, and the Amalgamated bought into it in 1912.[5]

Each of the six porphyry copper mines that has been so far mentioned, the four in the preceding paragraph and the Utah and the Nevada, consists of a huge blanket deposit of low-grade ore, finely disseminated in a porphyritic rock and overlain by more or less barren capping. In each case, the deposits have been carefully "prospected" by drills, and on the basis of the showing of tonnages and ore grades established thereby, plans have been made to extract the ore on a huge scale, and big plants have been erected at once on the spot for treating the ores. These plants were financed, not out of current earnings, as was the wont in the early days of Michigan, Montana, and Arizona, but by large issues of stock and of convertible bonds. Large-scale production being a *sine qua non* of profitable operation, this method had been imperatively necessary. What it achieved is shown by the figures of the outputs, in pounds of copper, of the six companies as early as 1915 and 1916, the latter of which years saw the peak figure of aggregate production for the group as a whole (tho not for most of the individual companies):

Company	1915	1916
Utah Copper	148,397,006	187,531,824
Nevada Consolidated	62,726,651	90,735,287
Chino Copper	64,887,788	72,319,508
Ray Consolidated	60,338,936	74,983,540
Miami Copper	41,832,059	53,518,331
Inspiration Consolidated	20,445,670	120,772,637
Total	398,628,110	599,861,127

4. Ibid., p. 981; Moody's Manual, 1915 (Industrial Section), p. 2723; Comm. and Fin. Chron., xciv, 126.

5. The first list of directors included Messrs. Cole, Ryan, E. C. Converse, W. E. Corby, and W. G. Rockefeller.

In 1915 they produced nearly 30 per cent of the total domestic output of the country, and in 1916 more than 30 per cent of the greatly enlarged production of the United States. Their production of 600,000,000 pounds in 1916 was greater than the copper output of the whole country in any year prior to 1900, and the increase in their output between 1915 and 1916, 200,000,000 pounds, exceeded the output of the country in any year prior to 1888. The production of these six mines in 1916 required the treatment of 28,627,000 tons of ore, which means that on the average less than 22 pounds of copper were recovered from each ton of ore mined and treated — a yield of barely one per cent!

It is desirable here to note that, apart from any other factors that made possible the profitable operation of the porphyries, no such success could have been attained, but for the discovery and application of oil flotation. This method of concentrating finely ground ore can be used only with sulphide ores. It consists of running the ground ore into a mixture of oil and acid, or some other substance, and agitating the whole. A froth like soap-bubbles forms, and the finely ground particles of sulphide ore are caught up in the bubbles and float off the top, while the gangue particles, tho lighter, sink to the bottom. Thus gravity processes used in water-dressing are reversed, since in these latter the heavier particles, containing the ore, slide down the sloped surface of the dressing-tables, while the tailings slip off at the top. Oil flotation was all important because it called for and made possible exceedingly fine grinding; and only such grinding enabled milling losses from the very low grade and extremely disseminated ore to be kept within such bounds as to make the exploitation of the porphyries feasible. Even so, in the early days of the Utah and Nevada mines, final re-

coveries of refined copper were only about two thirds of ore assays, a much lower percentage than obtained for higher-grade mines. In time, oil flotation came to be used by other sulphide mines than the porphyries, and has greatly affected not only dressing practices but also furnace operations, because of the problem involved in handling without losses the fine concentrates.

Meanwhile a remarkable development had taken place in Alaska.[6] As late as 1910 the territory produced only 4,000,000 pounds of copper. By 1915 this output had jumped to more than 70,000,000 pounds, and in the year 1916 the properties of the Kennecott Copper Corporation made 108,372,000 pounds of copper — incidentally, at a cost of only 5.1 cents per pound. Prior to 1911 practically the whole Alaskan output of copper had come from two districts in the south, Ketchikan and Prince William Sound. There had been discovered and developed an enormously rich mine in the Copper River region, a hundred miles from the coast. Commercial production awaited transportation facilities. The Guggenheim interests secured the mine — the Kennecott — and Guggenheim-Morgan capital built the Copper River and Northwestern Railroad, which reached the mine in 1911. Ore shipments then began. In 1910, the Guggenheims had secured the Beatson mine, the chief producer in the Prince William Sound district. The Kennecott Copper Corporation was formed in 1915, to acquire both the Kennecott and Beatson properties. The astounding richness of the Kennecott mines is apparent from the statement in the Kennecott Corporation's report for 1916, that the 297,843 tons of ore mined that year at Kennecott averaged 18.69 per cent

6. For the data in this paragraph, see volumes of Mineral Resources, and Application A-4549 for listing Kennecott Copper Corporation stock on the New York Stock Exchange; also reports of the Corporation, 1915 and 1916.

copper, of which 48,855 tons averaged 67.9 per cent copper. This contrasts with the yield in the same year for the six porphyries, noted a few paragraphs back, of a bit over 1 per cent copper. A similarly striking contrast is afforded by a comparison of the assays or yields of the porphyries with those of the Mother Lode mines near Kennecott, which began to produce in a small way, incidental to development work, in 1914. A majority interest in the Mother Lode Copper Mines Company was acquired by the Kennecott Copper Corporation and allied interests in 1918, and the Mother Lode Coalition Mines Company formed. Development of this property has been influenced by Kennecott's mill capacity and by the contract entered into with the Kennecott Corporation for milling the Mother Lode's low-grade ores. In the three years 1923–25, output averaged more than 31,000,000 pounds. The high-grade ore (of which about 10,000 tons are sent each year to the smelter) averages over 60 per cent copper. In other words, not far from half of the output of this moderately large producer comes from ore containing and yielding between 1,200 and 1,300 pounds to the ton of material mined.

The four years from 1910 to the outbreak of the World War witnessed the only other important mining developments that have occurred in this country and that have not yet been chronicled. There were three of these — all in Arizona.

Until 1914, the Jerome district had, so far as output of copper went, been virtually a one-mine camp. The great richness of the United Verde had naturally led, in the twenty-odd years since 1889, to much exploration, but it had been rather fruitless. It seemed as if Senator Clark had somehow had the luck to secure all the rich ground. In 1912, in spite of the history of the district, James S. Douglas secured an option on certain property

and instituted new exploratory work. In 1914 an extraordinarily rich, large mass of ore was discovered. Three years later, in 1917, the United Verde Extension Mining Company, which had been formed to operate the property, produced nearly 64,000,000 pounds of copper and paid its stockholders nearly $3,000,000 in dividends.[7] It has been a large producer and dividend payer ever since, altho it has never again reached the output of 1917, when war demands called for all possible copper output.

Down in Bisbee, at just about the same time that the discovery in Jerome was taking place, the Copper Queen was taking the first steps toward developing a big low-grade porphyritic deposit on its property in Sacramento Hill. Determination of reserves by a drilling campaign and treatment of small tonnages of ore in an experimental mill convinced the company of the economic feasibility of exploiting this deposit, with steam-shovel mining, somewhat after the fashion of operations on the great Utah Copper hill at Bingham, even tho the sizes of the respective ore tonnages of the two deposits were not at all comparable. Over the next five years or so, — in other words, through to the end of the war and into the post-armistice period of copper depression, — the barren capping was removed. Commercial operation of the concentrator (mill) erected to treat Sacramento Hill ores began only in 1923. In 1924, ore from the hill deposit produced nearly 50,000,000 pounds of copper, which compared with 59,000,000 pounds produced by the Queen's underground mines at Bisbee; in 1925 output was a few hundred tons less. Thus the new exploitation is comparable in output with the United Verde Ex-

7. See Rickard, in Min. and Sci. Press, cxvi, 9–16, and 47–52, and Lindgren, Bulletin 782, U. S. G. S., pp. 79 ff.

tension and, if it were a separate organization, would take rank as a rather large copper mine.[8]

The Queen's neighbor, the Calumet and Arizona, had meanwhile been developing another large low-grade deposit owned by the New Cornelia Copper Company, in which the Calumet and Arizona took a majority interest. This was at Ajo, in the very western part of Arizona, where production from rich, high-grade ores had taken place back in the eighteen-fifties. The deposit was in the midst of the barrenest of desert country, forty-five miles from a railroad. In certain respects, this has been the most interesting of the three recent Arizona developments. By 1913, the Calumet and Arizona had estimated that the ore reserves of some 40,000,000 tons, averaging about 30 pounds of copper to the ton, were economically available, more than two thirds of this being suitable for steam-shovel mining operations. The company determined to leach at least the important tonnage of oxidized ores; this would represent the first commercial application of hydrometallurgy to the reduction of copper ores on any scale in this country.[9] Experimental operations began in 1914. Then a railroad was built from Gila Bend to Ajo. Commercial production began with the completion of a leaching plant in June, 1917, and during that year 19,500,000 pounds of copper were produced, about two thirds being electrolytic copper deposited from the leaching solution. In 1918 the output was raised to nearly 47,000,000

8. Company reports, Mineral Resources, Poor's Manuals of Industrials, Moody's Analyses, and the 1925 Year-Book of the American Bureau of Metal Statistics are drawn on for the events and statistics of the last decade, unless otherwise noted.

9. Hydrometallurgical treatment of ores without the intervention of pyrometallurgy, or furnace operations, typically involves the lixiviation, or leaching ores (generally oxides) by an acid solution and the electrolytic deposition of copper from the solution. Before the war, the cost of hydrometallurgy was prohibitive. By-product acid has helped to make the process feasible.

pounds. Production was curtailed after the armistice, and not until 1924 was the 1918 output exceeded. In 1925, 69,000,000 pounds of copper were produced, more than half of this being leached from the ore. The New Cornelia is still the one outstanding example of hydrometallurgical production of copper from ores (not including leaching of current tailings or old tailings dumps) in the United States.

VI. 1914–1925

It is needless to say that in the last decade the war overshadowed all other events in the copper industry. The opening of hostilities, by cutting off the German demand and by its effect on industry generally, here and abroad, prostrated the copper industry. Curtailments up to 50 per cent, except at the Lake, were pretty general among the important mines in the fall of 1914. Lake mines curtailed less than this because in 1913 they had been through a rather severe strike, entailing serious losses in production, and the industry agreed, apparently, that the Lake should not be expected in 1914 to curtail as much as the others. Within a year thereafter, copper prices had risen sharply, and before we entered the war, copper had sold at well over 30 cents a pound. Chart I shows how production was stimulated. Old and new mines made their enlarged contributions to the total. In the fall of 1917, copper prices were set by the President at 23½ cents a pound, the figure being raised in 1918 to 26 cents. Then, as soon as the armistice was signed, there ceased to be a copper market, and for months no prices were quoted. The boom period of 1919–20 helped to sustain copper prices somewhat, but with the general collapse in 1920, copper fell, not only in sympathy with other commodities, but under the crushing weight of the enormous stocks of virgin and

fabricated copper in the hands of the former belligerents. The most drastic curtailment in the history of the industry took place in 1921, the smelter output of the United States falling to 253,000 tons, the lowest figure since 1897, and only 26 per cent of the 1918 output. Even with this curtailment, the price of copper went below 12 cents a pound, well under the pre-war level of prices. As Chart II shows, the price of copper in the five years since 1921 has averaged barely 14 cents a pound, hardly different from the average for the five years 1910–14, inclusive.

Copper has thus been one of the outstanding industrial commodities whose price since the 1920 crisis has afforded a marked contrast with a general wholesale commodity price level about half as high again as before the war. It would have been strange if post-war general wage and price levels had not affected operating conditions in an industry which sold its main product (copper) and even its principal by-products (gold and silver) at exactly or practically pre-war levels, while the yield of the ores beneficiated was tending steadily to decline. Effects of the price revolution have not been missing, but they have not been as great as they would have been if they had not been tempered by certain factors. Costs are higher, and margins of profit, to be sure, are lower than they presumably would have been had the war not occurred; and a projected pre-war trend of production brings one out at 1925 and 1926 well above the actual output of those years. That output is as high as it is, despite higher costs and greatly increased production by foreign mines, may be said to be due principally to the following factors:

1. A very substantial part of the copper output of the country had always been produced at a cost well below average selling prices, so that considerable slack could be taken up.

2. Metallurgical progress and improvements in mining methods, while not of such spectacular or revolutionary character since 1915 as before, have been going on all the time, reducing unit costs and increasing recoveries of metal from the ore; and fuller use has been made of the improvements antedating 1915.

3. The enormous surface and underground investments of the companies meant a rather large overhead expense, no small part of which could not be avoided by partial or total shutdowns. Therefore production might as well go on. In the case of some mines, permanently burning underground fires, or underground waters, or the necessity for replacing decaying timbers, or for doing other work to prevent cave-ins, or a combination of factors such as these, brings about an especially high underground maintenance expense, which is unceasing whether operations are going on or not.

4. To the extent that companies or affiliated interests had not only mines and mills but smelters and refineries, the urge to operate these reduction works as close to capacity as possible has been a factor tending to sustain production; the more so since there is surplus refining capacity in this country.

5. Of the fifteen largest producers in the United States in 1925, five properties, responsible for nearly 15 per cent of the total output of the country in that year, had contributed virtually nothing in 1913. Other, tho minor, new production has also come in.

6. Not far from half of the production of the country is now coming from mines which possess *only* low-grade deposits, of *such* low grade that successful exploitation is possible only with quantity production. Low prices might actually tempt some of these to increase rather than to decrease tonnage. Most of the other mines of the country are getting their copper from ore with

gradually declining and generally low copper yields and, metallurgical plants having been planned in recognition of this, even these mines tend to strive for regularized quantity production more or less independently of price fluctuations. The monthly mine production of copper since the middle of 1923 has been remarkably uniform.

Some of the older mines, however, are dropping back, absolutely or relatively. The first table in this article indicates the effect of this on state totals. The following table shows the 1925 outputs, in tons of copper, of the fifteen largest producing mines of the country, their record outputs in any year (with date), their outputs in 1916 (the year of maximum production for the country), their share of the country's output in 1925, and the share of the thirteen out of the fifteen to which production was credited in each of those years.

Company	1925	Output Record year	1916
Anaconda*	133,432	153,698 (1916)	153,698
Utah	107,081	107,247 (1924)	93,766
Copper Queen	58,190	58,190	51,383
United Verde	54,105	54,105	29,650
Calumet and Hecla	50,375	77,056 (1916)	77,056
Inspiration	40,972	60,386 (1916)	60,386
Ray	37,345	44,291 (1917)	37,492
Nevada	36,827	45,368 (1916)	45,368
New Cornelia	34,631	34,631	....
Chino	33,693	39,818 (1917)	36,160
Miami	25,926	33,727 (1922)	26,979
Calumet and Arizona	22,279	35,020 (1916)	35,020
United Verde Ext.	21,860	31,621 (1917)	18,201
Kennecott	21,404	54,186 (1916)	54,186
Mother Lode	15,138	16,483 (1923)	....
Total	693,258	....	719,345
% of U. S. Total	83%		
% of U. S. Total by 13	77%		75%

* Including a small output from custom ores.

It will be noted that nine of the fifteen mines are in Arizona and that all three of the mines for which 1925 represented new high record outputs are in the same state. The Queen's output has, of course, been increased by the production from the new low-grade exploitation. The Calumet and Hecla is getting just about 20 per cent of its copper production, not from its mines, but from retreating old tailings scooped out of Lake Linden; and of the other 40,000 tons or so credited to 1925, the old Calumet and Hecla mine produced distinctly less than it did annually forty years ago. Newly acquired subsidiaries account for the rest. And of course many other mines less important than the Calumet, both in Michigan and elsewhere, have found it impossible to maintain production at old levels, against higher costs and declining yields. It has been true throughout the last fifty years that a very large percentage of the copper output of the country has come from a relatively small number of mines. The composition of the "honor list" has changed frequently, however, and of the foregoing list, only five mines were fully developed properties operated on something like the present basis twenty years ago. On the other hand, none of the fifteen was first exploited as recently as ten years ago, and four of the five leaders of the 1925 list date back, or are in camps that date back, at least four decades as sources of copper; and these four are apparently in no immediate danger of displacement from their positions by new production in other camps.

As a final summary of copper production in this country, let us note the following table of aggregate output in the eight principal districts of the country. The table is based on data of the U. S. Geological Survey through 1923, with estimates for 1924 and 1925. As usual, the figures are in tons. Only those districts are

included which to date have produced 500,000 tons or more. These eight districts have turned out 14,770,000 tons of copper, 82½ per cent of the domestic copper output of the United States of the last eighty years, amounting to 17,900,000 tons, or 35,800,000,000 pounds.

District	State	Production began	Output	Percentage of U. S.
Butte.....	Mont.	1868	4,460,000	24.9
Lake Superior .	Mich.	1845	3,738,000	20.9
Bisbee.....	Ariz.	1880	1,655,000	9.2
Bingham	Utah	1896	1,415,000	7.9
Globe-Miami...	Ariz.	1881	1,215,000	6.8
Jerome	Ariz.	1883	940,000	5.2
Morenci-Metcalf	Ariz.	1873	815,000	4.6
Ely.....	Nev.	1908	532,000	3.0

The present article says little about the remarkable achievement of the copper industry in meeting the metallurgical and economic problems imposed by conditions within and external to the industry. Yields of copper ore in the early days have been mentioned, which ranged from 20 per cent up to 50 per cent or more. In the year 1923, the latest date for which Geological Survey figures are available, the estimated recoverable copper content of copper ore mined in the United States was only 1.58 per cent or 31.6 pounds of copper to the ton of ore. To produce the 717,000 tons of copper recovered that year, it was necessary to mine and treat 45,500,000 tons of ore. Compare these figures with the production in the same year of 40,361,000 gross tons of pig iron from 73,312,000 gross tons of iron ore! For the State of Utah alone the average copper yield was but .91 of 1 per cent. From ores of such content as these the United States is still producing more than one half of the world's output of copper, just as this country has done every year (with the sole exception of 1921) from 1895 on. To have written even a summary

history of copper mining without once mentioning the American Smelting and Refining Company may to many seem an inexcusable omission. But it is no greater omission perhaps than others that will readily occur to readers well acquainted with the history of the industry; as, for example, the whole question of our import and export trade in copper.

I hope in a later article to indicate some of the interesting problems of organization that the industry presents, as well as some of the bearings of copper history on certain points of economic theory; to clothe with life the skeleton which is here presented.

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NEW YORK CITY.

UTILITY CURVES, TOTAL UTILITY, AND CONSUMER'S SURPLUS

SUMMARY

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Recognized difficulties of dealing quantitatively, by means of demand schedules, with the subjective background of economic phenomena, 303. — Relativity of demand schedules to rates of consumption, 304. — Doctrines of consumer's surplus: (*a*) Bargain purchases of intra-marginal utility, 308; (*b*) The addition to one's total utility that attends a decline in price, 311; (*c*) Life's excess of utility over the disutility of earning a living, 313. — Résumé, 315.

THE group of conventional doctrines that center about the principle of diminishing utility rest essentially upon the notion that, as the supply of a good is increased, with an attendant falling off (after a certain point) in the utility added by successive increments, the utility of intra-marginal units is not, generally speaking, affected. Thus Professor Taussig states the point with great clearness:

> It may seem paradoxical to say that all the constituents of a stock have the same economic importance, and that none the less some have greater utility than others. But there is no real paradox. It must be remembered that utility means satisfactions or enjoyments. To possess a stock is not to enjoy it (except so far as, by association of ideas, mere ownership gives pleasure; as in case of a miser's hoard). The stock is necessarily enjoyed, not as a whole, but by installments; and as it comes to be so enjoyed, the successive installments yield lessening satisfaction. Economic importance is something different; it is the satisfaction dependent, not on the whole stock, but

on any one of the constituents of the stock. Considered in this way, all the constituents are alike; even tho considered as sources of enjoyment when actually used, they are of varying utility.[1]

I find difficulty in following this reasoning with reference to the great bulk of consumption. To the extent that it is true that at infrequent intervals one satisfies one's intense desire for a good by consuming in succession a large number of units of the article, the consumption of the first — orange, let us say — does indeed yield a great deal of satisfaction, much more than is derived from the consumption of additional oranges. Here, indeed, we do have the principle of diminishing utility working in a simple and direct way, with the result that we obtain a series of decreasing satisfactions, the sum of which is considerably greater than the product of the number of units multiplied by the satisfaction which the marginal yields.

But how generally, in reality, are the facts of consumption such as we have described? Most of our wants are satisfied, during periods of considerable length, more or less continuously, at a comparatively uniform rate. Oranges, throughout the season, appear on my breakfast table every morning. Once I have become accustomed to eating oranges with more or less regular frequency, is it true that the successive consumption of the several units of a week's supply is attended by de-

1. Taussig, Principles of Economics (1921), i, 121, 122. Other writers are not so explicit in making their treatment hinge upon the fact that a "stock" is used *by installments*. But they do accept the thesis, to which I take exception, that the total utility of a good whose several units are consumed in succession greatly exceeds, in general, the minimum enjoyment that is yielded by any one of the units multiplied by their number. Such a conclusion is impossible unless one holds that the several units, in the actual process of consumption, yield unlike magnitudes of utility.

It may be taken for granted that writers who, like A. Marshall and Professor Taussig, speak of a given supply have in mind — even tho they may not be explicit on the point — a supply distributed over a period of time, not necessarily consumed at one swoop.

clining enjoyment? Is it not true rather that, in actual consumption as in price-determining significance, the various oranges are indistinguishable in the satisfaction they yield?

The errors, it would seem to me, in much of the current treatment of the corollaries of the principle of diminishing utility arise from imperfect perception of that very fact which we so strive to emphasize, namely, the relativity of utility. We define utility as "the power to satisfy want," then proceed to reason as if this were something absolute, provided a certain supply of a good be given. But the utility that adheres to any unit of a good is relative not merely to the number of units which the consumer is to enjoy in any given period: it varies also with the amounts he has been enjoying in the recent past; that is, with the rate at which he has recently been accustomed to consume the article. Quantity, it is obvious, has meaning only as it is related to the interval of time in which it is to be consumed. And the measure of utility which a given rate of consumption affords varies with the extent to which the consumer has latterly been satisfying his want for the good. It is not enough to insist that utility — and likewise demand price — is relative to the magnitude of the stock; even given the latter, we must know the consumer's recent history with reference to the consumption of that good before we can draw a utility curve for him. The problem is one of *rates* of consumption — nay, to some degree even of *rates of change* in rates of consumption, for the conditions are dynamic. Few of us would be willing to pay fifty cents (the price Professor Taussig assumes) for a single orange unless our appetite for oranges had for some time been denied. And the enjoyment which we should then experience in consuming our first orange plays no part in determining the total gratification we obtain from

oranges in the absence of such denial. One's desire for griddle-cakes not only decreases with increase in the number one consumes on any given morning, but is also influenced by the number of mornings during the preceding week on which one had them, and to no small degree by the length of the period during which they were served with such regularity. The same rate of serving a given diet results in less utility after it has been maintained for a considerable length of time, than it did in the first week.

There is, in fact, ambiguity in our use of the word utility, and this lies at the very root of the matter. When we speak, for example, of the great utility that bread possesses (as we do in discussing total utility), we have in mind its *potential* capacity to satisfy an intense want under conditions of privation. On the other hand, when we compare the pleasure one enjoys with the price one has paid for a good (as we do in stating the doctrine of consumer's surplus), it is to satisfaction *actually experienced* that we mean to refer. And the two are by no means the same. The potential utility of bread is very great indeed, but the total satisfaction which it actually yields to the average consumer is far less. For the utility that would be derived from a slice of bread by a hungry man lost in the wilderness attaches to no unit of the bread consumed by members of my household, and plays no part in determining the total satisfaction which they derived from bread during the past year. Utility is a property in goods that has no meaning except in relation to man's desires, and these change in the presence of scarcity and abundance. In order that the potential capacity of a good to satisfy a want of great urgency should actually be brought into effect, the corresponding degree of want must exist.

The question here raised is that of the simultaneous

significance of different parts of a utility diagram as commonly drawn and explained. During a period throughout which the desire for a good is continuously satisfied, do the upper portions of the diagram, which in reality represent the utility that would attach to the good under conditions of scarcity, have any validity in the sense that they represent actual psychic income that is being enjoyed? Marshall and those who follow him most closely would lead us to believe that they have.[2] Thus Marshall speaks of a consumer "who, if the price of tea were 20*s*. a pound, would just be induced to buy one pound annually; who would just be induced to buy two pounds if the price were 14*s*.; . . . and who, the price being actually 2*s*., does purchase seven pounds."[3] He then goes on to assert (in an endeavor to prove that the total utility is measured by the sum of prices that would be needed to induce the purchase of the several quantities) that the purchase of the additional pounds does not affect the utility derived from intra-marginal units.[4] In other words, one of the seven pounds of tea

2. One exception to this statement should be noted. All writers recognize that the utility which attaches to a scarce and expensive good by virtue of its catering to one's love of distinction would attach to no unit of the good were it to become inexpensive and commonplace. To the extent, then, that the display instinct is the source of the utility derived from a good, the upper portions of its utility curve have effective significance only on the assumption that the corresponding conditions of supply obtain. See, for example, Taussig, Principles of Economics, i, 126; or Cunninghame, Economic Journal (1892), ii, 37–39. Some critics have gone further in modifying the doctrine of consumer's surplus along these lines. See Ely, Outlines of Economics (4th ed.), p. 153.

3. Principles of Economics (7th ed.), III, vi, 2, p. 125.

4. From some points of view it seems preferable to speak of intra-marginal units rather than additional, or successive, units. For the latter words imply an order in time, whereas it is my contention that there is no significance to such sequence (once a given rate of consumption has become well established) with reference to units that are distributed, in their consumption, at uniform intervals of time.

Somewhat similarly, since utility is a function of time as well as of quantity, there is clearer meaning, perhaps, in such phrases as "rate of consumption," and "intensive satisfaction of a want" (or "intensive

that are bought in a year when the price is 2*s*. yields the same satisfaction that it would afford "if the price . . . were 20*s*.," and it were the only pound purchased. But, "*if* the price . . . were 20*s*.,"—and the very phrasing of our hypothesis tells us that it is not, — the resultant consumption of a single pound of tea in a year would satisfy in a consumer a degree of craving that none of it *does* satisfy in the circumstances that exist when the price of tea is 2*s*. and a cupful greets him sevenfold as frequently — once a day, let us say, instead of on Saturdays only.

It is one thing to say that a unit of a commodity has the power, under conditions of scarcity, to satisfy an intense want; it is quite another thing to reason that like satisfaction attaches to any one of the large number of units of this good that are being consumed amid circumstances of plenty, and that this measure of enjoyment enters into the determination of the total of sensuous gratification actually derived from that good during the period in which it is being regularly consumed in large quantities. For we are like a man whose appetite is constantly near surfeit from continual self-indulgence — we derive from no part of the supply of more familiar goods the full amount of pleasure which, under different conditions, they would be capable of affording.

Nor is this decline of desire for a good, as one becomes accustomed to consuming it at a high rate, a change of taste of the sort that may be ruled out. For it is not as if we were to discuss the heightened utility, let us say, which six-inch cigarette holders possess because the Prince of Wales made them fashionable. The change in the consumer's gratification to which we are referring is

consumption of a good"), than there would be in speaking merely of quantity, unless one were prolixly to refer in each instance to the element of time.

no less a necessary accompaniment of the fact of consumption at a certain rate, and is no less a direct consequence of it, than is the diminishing psychic excitement experienced by the youngster, ensconced in the crotch of a tree, who belabors his stomach and beplasters his face with cherries that tomorrow will give him pain. In both cases a change takes place in the consumer, but it is a change which it would be as absurd to rule out as it would be to postulate that the activities of our youthful friend, in his lofty perch, had no bearing upon the number of cherries remaining on the tree.

Are we, then, to give up the notion of a total utility that is anything other than a mere function of marginal utility, and to hold that, at any given time and to any given individual, all the units of a good yield equal gratification? No such sweeping conclusion is implied. In every instance in which we have urged that at any single time the diagram depicting the total satisfaction derived from a given supply of a good should show a horizontal line, we have been careful to assume, it will be noticed, that consumption is proceeding at a continuous, smooth rate (to which the consumer has become adjusted) — that is, that the several units of the good are consumed at substantially equal intervals of time. Such are the facts in regard to the many commonplace goods of one's daily experience — the coffee, the tea, the morning's porridge and prunes, the after-dinner cigar, and the weekly visit to the theater. Capricious variations in the mood of the consumer, or in the quality of the things offered, may result in greater enjoyment from one unit than from another, but this is a different matter altogether. It is no more relevant to the point here at issue than are variations in the strength of individual laborers to the problem of explaining the gen-

eral level of wages for the unskilled workers of a country. And, so long as the consumption of a good is of the nature assumed, to give our total utility curve a downward slope is to mistake for actual psychic income a *potential* utility that would be realized only if the corresponding conditions of supply were to obtain.

But the consumption of many goods is not of the character thus described. Penrod does not satisfy the craving of a normal boy for rides on a roller-coaster with single rides at regular intervals. He does so, rather, on the gala days that mark his visits to the beach, by a successive dosing of his desire — a dosing that may call for a good many rides before he is ready to seek some other form of amusement. And these trips, like the numerous ice-cream cones that spending money makes possible on the Fourth, will yield a series of diminishing gratifications that may go well down the line before the ardor of youth has had enough. Here, clearly, there is immediate significance to the notion of a total utility that greatly exceeds the product of the marginal multiplied by the number of units. I recall the vivid picture which one of Penrod's older brothers, just returned from the trenches of France, drew of a walk down Fifth Avenue, arm linked in arm of a fellow — a walk that was punctuated by frequent recourse to the cooling sensation of "chocolate floats." Here, too, the joy of the first helping was allowed to diminish very greatly before the margin for stopping was reached.

In some measure such experiences are part of our daily life. The early strawberries of the season satisfy in the same consumer a higher order of want than does a similar bowlful some weeks later, after berries have once more become a familiar item in the day's menu. Such disparity of per-unit enjoyment is present in the consumption of all goods the supply of which is sea-

sonal. So it is when the laborer's wife takes advantage of a generous increase in his pay to serve steak for two meals a week rather than one, as in the past. For some weeks, presumably, there will be a tendency toward diminishing satisfaction from a steak dinner. But, after the new rate of consumption has become the accustomed one, can we say that steak served on Wednesday gives less relish than Sunday's portion, or that the first helping of each month is more highly esteemed than the last? [5]

Few economists, I take it, would question that the meat dinners with which some Italian families celebrate each week-end are essentially indistinguishable in the enjoyment they yield. Nor would many question that no differentiation would obtain, after the novelty of the new rate had worn off, between successive portions, if

5. There is a less significant aspect in which the phenomenon of diminishing utility manifests itself in such a way as to differentiate various portions of the supply of a good. The consumption of practically all goods is at least in some degree intermittent. Oranges are not devoured at one gulp, or coffee (or the water that may be had for the asking) by spoonfuls equally spaced in time. And, as one comes to consume commodities in comparatively large doses, the successive slices of orange, or puffs at a cigar (quite apart from changes in its quality as it shortens) commonly tend, toward the end, to please the consumer less. Witness the unfinished additional helping of pie for which we have sometimes asked from miscalculation of appetite.

This lack of perfect continuity of consumption, even with reference to things of daily enjoyment, is due, quite aside from the impossibility of tending to all wants at once, in part to habit and in part to the fact that our desires do not grow, or at least not sensibly so, by infinitesimal gradations of intensity. It requires a certain magnitude of want to force itself upon our attention. Moreover, from a principle of inertia that is as familiar to physical science as it is to the psychological, we do not respond to a desire as soon as its existence in the least degree is apprehended. Other contributing explanations might readily be thought of. But, after all, the diminishing utility that is experienced in the drinking of a cup of coffee, or in the consumption of one conventional unit of any other good, is not of great significance to the economist. The doctrines of total utility and of consumer's surplus concern themselves primarily with "doses" that are either the conventional unit of purchase or major fractions thereof.

through good fortune meat came to be served daily. But to grant this is to reject the commonly accepted notion that the total utility of meat would in neither case be comprehended by the marginal utility (that is, after the transition period, the utility of any single unit) multiplied by the number of units.

The principle of diminishing utility, then, operates in such a manner as to differentiate the several "doses" of a good only during periods of change from long-established rates of consumption. Graphically this means that, except during such periods, if we ignore capricious variations in the enjoyment yielded by the several units, total utility is indicated by a rectangle. A heightened rate of consumption implies a less than proportionate increase of utility, *but it signifies this in increasing degree as the novelty of the new rate wears off*. And, ultimately, the total utility yielded by a given number of units will once more be measured by a rectangle — a rectangle of lesser height (indicating smaller per-unit utility).[6]

Now observe that even in periods of transition, during which our utility curve does have a negative slope and total utility is something more than a function of the marginal, the height of our curve ranges only from the per-unit satisfaction that the old rate implied, to the per-unit satisfaction that soon becomes a consequent of the new rate. And, except with reference to those things (like Penrod's joy rides) the consumption of which is sporadic, and with the further exception, tho to less degree, of goods that may be had only during

6. It is even possible that a greater rate of consumption, by effecting a more than proportionate decrease in per-unit gratification, will ultimately bring about an *absolute* decline in total enjoyment. A little reflection on one's own experiences will probably convince that this is by no means implausible. According to Marshallian analysis the consumption of a greater quantity during a given period could cause a decrease of total utility only after the point of disutility had been reached.

brief seasons, this represents a very considerable modification of our conception of total utility. It leaves, in the case of most commodities, an area on our utility diagram that is uninfluenced by the extremes of potential utility that would be realized in any circumstances of consumption that fancy may conceive — an area that is affected, for any given period, only by such magnitudes of utility (in turn dependent on rates of consumption) as were actually experienced during the interval in question, each magnitude taken as many times as there were units to which it referred.

We may further picture the facts of diminishing utility with a curve having a negative slope and looking not unlike the one now commonly used, by letting our horizontal axis represent, not quantities, but rates of consumption, and by measuring on the vertical axis the per-unit satisfaction that accompanies each rate after the freshness of that rate is no longer a factor. But it should be recognized that the several points on such a curve are not simultaneously effective, for that one only pictures the facts of psychic income which corresponds to the rate of consumption that is actually obtaining.

In the light of the foregoing argument, how shall we deal with the doctrine of consumer's surplus? Here is a concept based primarily on the notions, first, that what we have called the intensive consumption of a good is attended by the realization of greater utility from the intra-marginal units than is afforded by the marginal; secondly, that since price measures the marginal utility, the consumer pays for only this least magnitude of satisfaction multiplied by the number of units of the good. He therefore gets more utility than the purchase price in his case represents. Baldly stated, the con-

sumer parts with less utility than he receives in return.

In turning to this doctrine we are no longer able to discuss utility in the subjective directly, as we have thus far been doing, by begging the difficulty of finding a yardstick for its quantitative measure. For the doctrine of consumer's surplus necessarily runs in terms of media of payment.

As Marshall himself amply cautions us, inequalities of incomes, and differences of sensibility to abundance and deprivation, render difficult the attempt to read into the demand schedule of a group of individuals any subjective interpretation. And even when we turn to the demand curve of a single person (in which case it should more properly be drawn as a broken, "staircase," line), a troublesome hiatus remains in interpreting demand price as a measure of anticipated utility. In the first place, it is a one-at-a-time procedure that is involved, for the amount of a commodity that any person will buy at a given price depends largely upon the current prices he must pay for other things. With a stated income, any considerable change in the other prices that enter into the determination of his cost of living will alter a buyer's demand for the commodity in question. His demand curve cannot be drawn unless other prices be assumed to remain unchanged, or to fluctuate, if at all, within very narrow limits.[7]

7. Marshall's whole reasoning is based on the assumption that the change in price that is under discussion in each instance, while it necessarily affects the marginal utility of money, does so in such slight measure as to permit us to ignore this influence as one that is of second order of importance. It is this assumption which is at issue, for example, in Professor Allyn A. Young's observation (see Ely, Outlines of Economics, 4th ed., p. 153) that the demand curve tells us simply that a given individual is willing to buy one cord of wood at ten dollars, or two cords at seven, but does not tell us that he would be willing (as Marshall's analysis implies) to give ten *plus* seven dollars for the two cords. By limiting the application of his analysis to one good at a time, and by ruling out (III, vi, 4, p. 132) goods that take a considerable portion of one's income,

To these recognized difficulties of giving subjective interpretation to demand schedules we may now add another. If it is true that the utility which one derives from a given supply of a good is dependent upon his state of past familiarity with it, the demand on the part of any individual for that good, to the extent that it reflects the facts of diminishing utility, cannot be discussed simply in terms of quantity. Like utility curves, diagrams of demand can be drawn only if we know the rate at which the good has recently been consumed and the rate at which the supply is now to be consumed. The more fundamental choice implied by a change in price is one not of quantity, but of rate of consumption (that is, of quantity relative to an interval of time), and this choice is itself affected by the rates at which the article has recently been consumed. Our returned soldier bought, not four ice-cream sodas, but four ice-cream sodas in one day! and this was more than he would have purchased at the same price had not his craving long been balked. Moreover, even in the absence (thanks to rugged health) of untoward consequences, this was undoubtedly more than he bought the next day, and exceeded by probably a still greater margin his daily consumption a week later.[8]

Marshall is able to make a deceptively plausible case for his implied contention that, since one generally receives as much satisfaction from a cord of wood *per se* whether it cost ten dollars or seven, the three-dollar difference in his expenditures would not alter his decision to buy a second cord for seven dollars. But this argument is valid exactly in proportion as the significance of the assumed change in price is slight in relation to one's total budget, and the importance of Marshall's very thesis is, in consequence, correspondingly small.

8. Professor Allyn A. Young (who was kind enough to read this paper, for helpful criticism, in the manuscript) has told me of a New England farmer, shrewd in homely economic wisdom, who points out that his strawberries and asparagus fetch a lower price than they otherwise would because the native product is brought to market only after the edge of the early season's appetite has already been dulled by inferior produce from the South that sold at a higher price.

Returning once more to the examination, in the first part of our paper, of the manner in which the tendency of diminishing utility operates, how does this analysis affect the notion of consumer's surplus? The received qualifications of any naïve attempt to measure consumer's surplus on a demand diagram, substantial as they are, emphasize merely the inaccuracy of demand prices when used as measures of psychic enjoyment, and point out the care that must consequently be taken when we attempt to read into our objective data the subjective facts that lie beneath. They leave essentially unquestioned the notion of a total utility which, by virtue of the law of diminishing utility, is quite different from the product that would be obtained by multiplying the satisfaction derived from the marginal unit by the number of units. But we have contended that this very subjective concept, quite aside from the accuracy with which demand schedules picture it, is itself far less generally applicable than is commonly supposed. If the several units of a good that has long been enjoyed in small doses at certain regular intervals all sink in their psychic significance to a common level, it is only during transition periods — for example, while a new rate of consumption is bringing the increased purchasing power which money has for that good into harmony with the individual's marginal utility of money in the general field of exchange — that a consumer's surplus of the sort commonly described would seem to appear.

There are certain other sources of such consumer's surplus. For Marshall's doctrine — a mixture of several notions, as we shall see — has regard not merely to differentials of utility resulting from the several dollars spent in the purchase of a single good, but also to differences in the effectiveness of dollars in commanding

utility when spent for distinct commodities. Even tho it be granted that the different portions of the supply of a commodity are indistinguishable in the enjoyment they yield, it may yet be urged that a consumer's surplus is gained from the supply. The marginal unit may itself afford a measure of utility that exceeds by several-fold the gratification derived from other goods that cost as much. Most of us would surely feel that this is commonly true of ink, matches, bread, breakfast cereals, and many other articles which we should consume just as freely were the price to increase 20 per cent. Of similar origin, in sharper form, is the surplus which Marshall, to point his argument, attributes to the use of a bridge, for which the toll is one penny while the service rendered is worth to the user a full shilling.[9] For here the first unit is also the marginal; the man would not retrace his steps (until other occasion arises) were the bridge free of toll. Total utility, in this instance, and marginal are one. The principle of diminishing utility has nothing whatever to do with the toll-payer's surplus of utility, and there is something of confusion on Marshall's part when he cites the case in support of the contention that one of my seven pounds of tea, cheaply purchased, gives me the same satisfaction that it would yield were the price so high that tea became a luxury of of infrequent enjoyment.

There is a third source of bargain utility that is entirely consistent with the thesis that, for commonplace commodities, the notion of a series of declining satisfactions ill fits the facts. Even tho we have a good whose consumption is distributed smoothly and more or less continuously through time, and some of which is purchased by the consumer only after considerable hesitation, there yet may be an element of consumer's surplus.

9. Principles of Economics, III, vi, 2, p. 127 n.

For a commodity is frequently susceptible of many different uses, and a surplus of utility may be gained from all the units, equi-pleasurable, that are devoted to one use, while the units utilized for a different purpose may at once be homogeneous and marginal in the satisfaction they afford. Thus the familiar notion that "salt is cheap," to which Marshall refers as an illustration of consumer's surplus, bears witness to the fact that our use of this article for seasoning food is comparatively unaffected by its price, while its use to avoid the weeding of a driveway may be one of those expenditures that the same individual considers to be of marginal desirability. Subject to the qualifications we have already amply emphasized, the total utility of a good in each of its several uses may be the product of its marginal utility for that purpose times the number of units so utilized, and of these subordinate totals that go to make up the aggregate utility of the good as whole, some may indicate a surplus and others not.[1]

1. Marshall himself offers abundant evidence that consumer's surplus may obtain quite independently of the existence of differences in the magnitudes of utility that attend the consumption of the several units of a good. Such is the substance of his observation that "just as the demand of the rich for peas is considerable even at a very high price, but loses all elasticity at a price that is still high relatively to the consumption of the poor; so the demand of the individual for water to drink is considerable even at a very high price, but loses all elasticity at a price that is still high relatively to his demand for it for the purpose of cleaning up the house. And as the aggregate of a number of demands on the part of different classes of people retains elasticity over a larger range of price than will that of any individual, so the demand of an individual for water for many uses retains elasticity over a larger range of prices than his demand for it for any one use." (III, iv, 4, p. 108 n.) To say that the demand for a good "loses all elasticity" is to concede that the marginal unit may yield bargain utility. Peas, if their price be low, do so for the rich with reference to the marginal unit in general; whereas water, according to Marshall's statement, affords the poor man an extra measure of utility with reference to the marginal unit for drinking purposes, even tho for house-cleaning its price dictates sparing use. Again, consider what Marshall has to say (III, iii, 5, p. 98) concerning the finite gradations by which one's demand for a good grows. All this is evidence

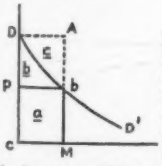
To Marshall these elements of surplus utility constitute a sort of bounty to the consumer, an excess of utility enjoyed over that paid for.[2] To the present writer this does not seem an entirely valid point of view. Bargain utility would seem to be a more accurate description. The utility of money — save to the gloating miser, who makes an end of what is more properly a mere means — is but the utility derived from the goods which it purchases. Now it happens that money is more effective in commanding utility in some instances than it is in others. In ideal theory, as a first approximation, we conceive an equalization of the utility derived from the marginal expenditures of money units for each of the countless goods we buy. Consumer's surplus represents bargain purchases of utility on terms more favorable than those that obtain at this (let us call it) iso-utilitarian margin. But it is a surplus which (like the notion of bargain) arises entirely from the viewpoint of comparison. Certain dollars give us, in their expenditure, an excess of utility over that yielded by other dollars, *because these other dollars give us less.*

There is a parallel here to the phenomenon of rent. After we have applied a certain number of our dollars to the purchase of enjoyment, we find that, thanks to the law of diminishing utility, no more opportunities are available for the exchange of dollars for pleasure at equally favorable rates. We must now either buy other goods, the initial units of which satisfy, per dollar, a less urgent desire than we have hitherto been able to gratify

of our imperfect ability to bring expenditures for several purposes to a margin of equalized per-dollar utilities, arising from the discontinuous nature of our demand for certain things. (Compare, also, in Marshall's Principles, p. 126 n.)

2. See Principles of Economics, Appendix K, p. 830, where Marshall refers to consumer's surplus as "the excess of the total utility to him of the commodity over the real value of what he paid for it."

with each dollar, or (spending intensively rather than extensively) we must consume more of the same good, with similar shrinking of the advantageousness of terms. In either case the terms of the earlier purchases are rendered *comparatively* generous. Consumer's surplus, then, emerges because of a principle of illiberality in our psychological make-up, and we must substitute, it would seem, somewhere in our formulas of consumption, a Ricardian notion of niggardliness for the Physiocratic notion of bounty.[3] In each case — in the analysis of consumption and of rent — that which we call a surplus, tho most readily measured, and its magnitude explained, as an excess over the minimum quantity involved, is more philosophically to be regarded as finding its origin in a deficit.[4] In each case the intra-marginal excess tends to increase, generally speaking, not because of improvement in the terms of exchange within the margin, but because of *impairment of the terms that obtain at the margin*.



3. Graphically we may explain the point by saying that Marshall would lead us to believe that, in consequence of the principle of diminishing utility and of the fact that it is marginal utility that governs price, the consumer is to be congratulated for receiving the utility indicated by the triangle *b* without paying for it. Rather should we commiserate him for being unable to benefit from a drop in price (or increase of his income) to the extent of the area represented by both *b* and *c*.

4. From the point of view of the individual, to be sure, rent is to be explained in terms of a "producer's surplus," and the arithmetic of the phenomenon is most easily explained in terms of excess. But from the social point of view (with which our theory of rent is chiefly concerned) it is more fundamentally to be regarded as the corollary, in the field of distribution, of a phenomenon of deficit. To deal with the quantitative aspects of rent in terms of deficit, one would have to resort to such circumlocutory practice as would be involved in assigning to the "best" land the deficit which the product on the margin shows in comparison, and in assigning to intermediate grades this amount minus their corresponding deficits. At least this would have the merit of indicating how attenuated is the sense in which we use the word product in referring to land.

Moreover, if our analysis of the sources of the phenomenon is correct, this bargain utility, far from being a happy accompaniment, even in an attenuated sense, of our efforts to bring expenditures for all goods to an iso-utilitarian margin, results largely from obstacles to the perfect realization of this goal. Our returned soldier, on whom we have drawn so repeatedly for illustrations, enjoyed a surplus utility from ice-cream sodas because he had long been denied the opportunity to spend for this delight money that was in consequence devoted to less desirable purchases. So it is with the surplus we get from early supplies of all seasonal goods. Their unavailability, compelling us to concentrate our purchasing power on fewer goods, forces our iso-utilitarian margin down lower. It is as a result of this mischief, and while we are bringing our expenditures for the good that had been denied us to the iso-utilitarian margin, that intramarginal surpluses of utility appear.

Confused with the notion of a bargain, supposed to be realized as a bounty by the consumer, may be found in the exposition of many writers quite another concept of consumer's surplus. Thus Marshall, in answer to a criticism by Nicholson, grants that it is of no avail "to say that the utility of an income of (say) £100 a year is worth (say) £1000 a year. . . . But there might be use, when comparing life in Central Africa with life in England, in saying that, tho the things which money will buy in Central Africa may on the average be as cheap there as here, yet there are so many things which cannot be bought there at all, that a person with a thousand pounds a year there is not so well off as a person with three or four hundred a year here." [5] It is the grand

5. Principles of Economics, III, vi, 2, p. 127 n. See also J. S. Nicholson, Elements of Political Economy (1903), p. 373; A. L. Bowley, Economica (June, 1925), xi, 138.

total of the utility commanded by one's income that Marshall has in mind here, and the increase of this grand total, as an increase in the effective diversity of things available for choice checks the tendency of the marginal utility of money to fall.[6] And, after all, a similar comparison of the totals of utility derived from one's income is implicit in Marshall's definition of consumer's surplus as "the excess of the price which [one] would be willing to pay rather than go without the thing, over that which he actually does pay." [7] For one "would be willing," if he had to, to pay all his possessions for the minimum of things necessary for his survival — unless, to be sure, he preferred death to continuing life empty-handed. The utility that is purchased by so much of his wealth as one does not, in actual fact, spend for the survival minimum, measures his benefit from the difference between the actual circumstances and those assumed.

Similarly, there runs throughout Marshall's chapter the notion that, as the price of a good falls, the consumer, upon satisfying exactly the same wants as before, now finds a surplus of money available for the gratifying of some less imperious desire, hitherto unsatisfied. From the present point of view there is this much validity to Marshall's assumption, frequently criticized, that the marginal utility of money is not significantly affected by the cheapening of a commodity: the sum of purchasing power that is released by the drop in price, altho it procures (particularly if it is a relatively large fraction of one's total wealth) less utility than is proportionate to what was formerly marginal, cannot fail, if we grant that our wants are insatiable, to place addi-

6. More accurately, of course, the utility derived from the marginal use of money.

7. Marshall, Principles of Economics, III, vi, 1, p. 124.

tional utility at the command of the consumer. And this addition of utility, regard being had to reactions on the pleasure derived from the wants hitherto satisfied, measures the surplus of psychic income realized in the one case over that enjoyed in the circumstances of higher price first assumed.[8]

The consumer's surplus, then, from the cheapening of any good, is the increase in the total of one's psychic income which results from that cheapening. But are the subtleties of Marshall's doctrine, with its intra-marginalisms, its hypotheses, and its qualifications, necessary to so elementary a notion? Not only are they unnecessary — they are irrelevant to it. For these two versions of consumer's surplus have little in common. Marshall's concept of bargain utility — founded largely on error, I have urged — is a derivative of the tendency of diminishing utility; the phenomenon of increase in total utility proceeds *in spite of* that tendency. The one (intra-marginal utility) increases as a lessening in the number of available choices, by concentrating consumption on fewer goods, lowers the margin which is the basis of comparison; [9] the other (net balance of total utility) increases as enlargement of the variety of choices

8. Instead of referring to the larger total of utility which one's income procures him by virtue of the fact that the price of a good is lower than it might be, we may think of the additional enjoyment which the existing circumstances give the consumer over and above what he could obtain with the same income were the good in question not available at any price. This version, too, is present in Marshall's all-embracing statement; for in one place he conceives the consumer's surplus derived from a good as the benefit one would lose "if his surroundings were so altered as to prevent him from obtaining any supplies of the commodity, and to compel him to direct the means which he spends on that to other commodities (one of which might be increased leisure) of which at present he does not care to have further supplies at their respective prices." Appendix K, p. 830. Compare W. E. Johnson, Economic Journal (Dec. 1913), xxiii, 490, 491.

9. This interesting paradox, illustrative of the purely relative nature of Marshall's concept, is suggested by S. N. Patten, "Theory of Dynamic Economics," in Essays in Economic Theory, pp. 77 and 86.

permits one to secure greater utility with the purchasing power that is released by any assumed decline of prices. Marshall would find no cause to congratulate the consumer upon the receipt of an intra-marginal surplus if, in the absence of the phenomenon of diminishing utility, a drop in prices brought a proportionate increase of one's total utility. Yet the consumer's surplus in the sense of enhancement of one's total satisfaction would in that case be of far larger magnitude than it is in the actual circumstance, with a tendency of diminishing utility in operation.

Yet a third conception of surplus utility remains to be mentioned. We may go a step beyond the question of the sum total of utility which one's monetary income procures and compare this with the disutility involved in gaining that income.[1] We should thereby be attempting to determine the net balance of the sweetness that life brings over the irksomeness of its toil. By endeavoring to assign a real-cost significance to successive increments of one's income, and by comparing the results with the utility gained in the spending of that income, we should arrive at a concept that is, in the abstract, more significant than either of the two preceding versions of a surplus. And, whether we assume a Crusoe whose own labors are the direct source of the goods he consumes, or take the familiar case of a society in which division of labor and monetary incomes prevail, we shall find that successive hours of labor involve, generally speaking, increasing irksomeness, while the additional wants they make it possible to gratify are of decreasing urgency. An individual, to the extent that free choice and wise calculation govern his action, will seek to work only to the point at which the irksomeness

1. See, for example, Marshall, Principles of Economics, Appendix K.

of effort has risen to an equality with the marginal utility its product is expected to contribute; and since, proceeding backwards within the margin, the product of an hour of labor increases in utility, while the irksomeness of its production decreases, a surplus of positive utility is realized.

This is an attempt to get away from the purely relative nature of Marshall's bargain concept of consumer's surplus. We are now seeking to attach to the dollar a magnitude of psychic importance that is independent of the utility it derives from the goods that it purchases. The whole of the excess of positive utility which any individual may be found to enjoy is not, of course, to be labelled consumer's surplus, for it is more truly a combination of producer's surplus and consumer's surplus. We may designate as consumer's surplus (with reference to a specific good) only such net balance of utility as would remain were the good produced with labor that is entirely of marginal irksomeness. Any positive balance that results from the fact that some labor is of less than marginal disutility is more properly to be regarded as producer's surplus.

This notion of a net balance of utility involves, in intensified form, all the difficulties that appear on the subjective approach. Nor can we apply it with nice measurement to any given instance. The concept is of interest, even if merely in the abstract. But please notice again how little such a concept — of a real surplus of total utility from life as a whole — has in common with Marshall's doctrine of consumer's surplus from several goods dealt with one at a time. It is in no sense dependent on the notion of differentiation in the utility realized from the various units of a good when those units are constantly being consumed at more or less uniform intervals. Once more we find that the law

of diminishing utility, basic in the one case, enters into determination of the other surplus only in an obstructive rôle.

Let me briefly summarize the views set forth in the preceding pages. The current treatment of utility fails adequately to recognize the relativity of utility. Enjoyment is a function of the rate of consumption, and were the successive units of a good consumed at equal intervals in time, their utility would be uniform. Total utility, as currently explained by many writers, ascribes to intra-marginal quantities of a good the potential utility that would actually be enjoyed only if the rates of consumption that made these units marginal were in reality to exist.

Since, however, goods are not consumed in doses of the minimum quantity conceivable, each dose separated from the preceding by a constant interval of time, it is true that different portions of the supply consumed in a given period do, in some measure, result in different degrees of enjoyment. But these variations, with the exception of goods whose consumption is sporadic, and with the further exception of seasonal goods, are far less considerable than is commonly supposed.

Marshall's doctrine of consumer's surplus, then, must be materially modified. The consumer does obtain some utility at peculiarly advantageous (intra-marginal) terms during transition periods — that is, between the time when a cheapening of price, or the return of a season, first causes him to consume a good at an unwonted rate, and the time when a unit has fallen to the marginal utility that the new rate implies. He also obtains utility at unusually favorable terms in the case of certain goods whose marginal unit in general, or whose marginal unit for one of its several distinct uses, affords greater utility

than he obtains with like expenditure in the field of exchange at large. But to regard these surpluses as indicating that the consumer obtains "more than his money's worth," is to forget how purely comparative is the basis on which they appear. Moreover, since these relative surpluses emerge by reason of a principle of niggardliness in man's psychological make-up, we must be careful how we interpret them, or we shall find ourselves congratulating the consumer on the inferior magnitudes of utility which his less eligible expenditures bring.

Confused with this notion of surpluses in the intramarginal members of a hierarchy of diminishing utilities is that of an increase in the total utility that one's monetary income brings as any fall in price occurs. But this phenomenon is needlessly sophisticated by Marshall's other doctrine, just considered, and the two, furthermore, are quite distinct. The one is a corollary of the tendency of diminishing utility, while the other is affected by the tendency in but an obstructive way.

We may also attempt to compare the net balance of utility that consumption brings with the net balance of disutility involved in earning the means of consuming. This procedure breaks away, in some measure, from the purely relative basis of the two foregoing computations, and gives the concept of a more real surplus. Aside from the difficulties, however, of removing it from the realm of the abstract, this concept too has little in common with Marshall's primary doctrine of consumer's surplus.

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THE INFLUENCE OF THE ANGLO-FRENCH TREATY OF COMMERCE OF 1860 ON THE DEVELOPMENT OF THE IRON INDUSTRY IN FRANCE

SUMMARY

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At a time when the majority of Frenchmen are more strongly convinced than ever that the maintenance of a high tariff is a vital necessity, it is interesting to observe what happened when they were obliged to submit to a liberal reform imposed by the virtually despotic government of Napoleon III. The French tariff in 1859 still maintained the policy of the Restoration period: it not only levied high duties, but positively forbade the importation of many commodities. Then, in January, 1860, came the sudden removal of all the prohibitions and the reduction of the duties through the signature of the treaty with England negotiated by Michel Chevalier and Richard Cobden. The manufacturers of cotton and iron goods in France, who had profited most from the monopoly of the home market, protested vigorously against the reform of the tariff and assured the government and the public that they would be ruined. The iron masters, through their national

committee, even told the Emperor that their industry would be completely destroyed if British iron were allowed to compete with theirs in the French market, and that the unemployment created would be so great that France would have to declare war in order to put an end to the iniquitous treaty of commerce.[1] While these statements were greatly exaggerated, it was not unreasonable to expect that the iron industry of France might suffer severely when it encountered foreign competition for the first time. In the case of the French cotton industry it is difficult to determine the effects of the reform of 1860, because a severe crisis was brought on by the American Civil War, with the resulting cotton famine; but the iron industry was not directly injured by the war. We can, therefore, more profitably study its development under the moderate tariff of 1860. The documents from the Ministry of Commerce at the Archives Nationales, and the valuable book prepared in 1914 by the Comité des Forges[2] to celebrate the fiftieth anniversary of its organization, will show us what the French iron industry had to contend with in the later years of the Second Empire because of the new commercial policy of France.

The development of the industry before 1860 had been very slow. This was due in great part to the monopoly of the home market enjoyed by the producers; but there were other causes. France was then working many small deposits of iron scattered widely through the country, with few rich mines of great depth. As a result, the industry could not concentrate easily,

1. Moniteur Industriel, Jan. 19 and 20, 1860. See also Petition of Léon Talabot to Emperor, Jan. 20, 1860, in Archives Nationales F 12-2514.

2. Comité des Forges: La Sidérurgie française, 1864–1914. Privately printed, 1920 for Iron-masters' Assoc. A copy was seen through the courtesy of the Secretary of the Comité des Forges, M. Desportes de la Fosse.

and iron was mined, smelted, and refined in a large number of very small establishments. Another cause of retarded development was the inadequate system of transportation, which made it so costly to move the ore, and even the pig iron, that most of the manufacturing of iron had to be done close to the mines. The same lack of adequate transportation forced the iron masters to use such fuel as they could find close to their furnaces and foundries. In most cases that fuel was wood (that is, charcoal). France had abundant forests, owned in part by the national and local governments, which were, therefore, interested in selling wood to the iron masters, and in part by the masters themselves. Owing to this abundance of wood, the French manufacturers were not obliged to develop the smelting and refining of iron with coal, unless deposits of coal were so near their foundries that their use would be notably cheaper than that of wood. One of the greatest stimulants to the improvement of the methods of smelting and refining iron in England, the scarcity of wood, was thus lacking in France. A few French establishments which were near coal deposits, or owned coal mines themselves, as did the great firm of the Schneiders at Le Creusot, improved their methods and increased their production through the use of coal and coke. But the great majority of the French firms continued to use wood. Some could not get coal in sufficient quantity or at a moderate price, but many knew nothing of the economies that the use of coal offered. Only as the establishments using coal grew in size and in the amount of iron they produced, did they gradually bring pressure to bear on the smaller firms using wood. The change of fuel in France made slow progress, partly because coal was neither abundant nor cheap in most places, and partly because the prohibitive tariff enabled all manufacturers to charge

such high prices that iron could be produced at a profit by the most antiquated and costly methods.

The greatest stimulant to the development of the French iron industry before the invention of the Thomas-Gilchrist process for the manufacture of steel in 1878 was undoubtedly the construction of the railroads. A drastic reduction in the cost of transportation resulted, which brought down the price of iron. This made itself felt with increasing force when order had been restored after the Revolution of 1848, that is, in the decade preceding the Treaty of 1860, when most of the main railroad lines were built. The construction of the railroads stimulated the iron industry also through the demand for rails, which became so great after 1850 that the metallurgical establishments of France could not meet it and large importations had to be authorized by the government.[3] As a result of these developments the manufacture of pig iron was largely transformed.

3. The length of the railroads in France increased between 1850 and 1860 from 3008 to 9442 kilometres; by 1870 the total was 17,476. See de Foville, Transformation des Moyens de Transport, p. 18.

For authorizations to import rails see Enquête, March, 1854, by Ministry of Commerce (Archives Nat. F 12–6408). Beginning with the Decree of Nov. 18, 1854, permits were granted in urgent cases, until 1858. The government usually levied a duty equal to the difference in cost of production between England and France. This was ordinarily between 60 and 80 francs per ton, whereas the normal duty was 120 francs.

The French producers do not seem to have been entirely to blame for the delays in furnishing rails. They complained that the railroad companies gave large orders suddenly for quick delivery and then waited for months or years before giving new orders, so that there was no regularity in the demand that would justify a permanent increase in production. On the other hand, the evidence of railroad directors like P. Talabot and Emile Péreire (see Enquête, 1860, Traité avec l'Angleterre, vol. i, pp. 197–224) shows that the iron masters combined to charge monopoly prices. If rails were wanted for a line in the south a contract was signed with a firm in the north, and the railroad company paid for the transportation of the rails to the south; but the rails were really made by a foundry in the south and the profits were divided. The railroad companies had to submit to this arrangement and take what quality of rails the iron masters chose to supply in the hope of getting the rails quickly.

Three quarters of it was made with coke in 1864, the amount being 876,000 tons, compared to 224,000 made with wood, and 113,000 with coke and wood mixed. Only two French furnaces had used coke in 1819, of which one was Le Creusot; in 1830 there were 29 out of 408 furnaces making pig iron with coke; in 1840, 41 out of 462; in 1856, 120 out of 591; in 1865, 147 out of 413. The use of wood as fuel, while it showed no increase after 1824, showed no marked decrease until 1860. But the use of coal and coke increased steadily, the production of pig iron with this fuel being only 1000 tons in 1819, and 706,025 in 1865, out of a total output of all forms of fuel of 792,058 tons. In short, long before there was an absolute decrease in the use of wood there was a relative decrease as compared to coal and coke.[4]

A study of the principal regions where iron was manufactured in France will show even more clearly the degree of development attained by the industry when, in 1860, it was called upon to meet British competition. The most important region in France is now the east, which, for convenience, we may refer to as Lorraine. Here the Department of Meurthe and Moselle alone in 1912 produced 2,200,000 tons of steel, which was 50 per cent of the national production of that year. In pig iron the dominance of this district was even more pronounced, for it made 3,400,000 tons out of 4,900,000, or 69 per cent of the national production. The same department produced more than 90 per cent of the iron ore mined in France. The overwhelming importance of Lorraine was the result of the invention in 1878 of the Thomas-Gilchrist process, which made available the phosphoric ore of that region. Before that date, altho the mining and manufacture of iron in Lorraine can be traced back to 1320, the region was one of the least im-

4. Sidérurgie, p. 120.

portant in France. Its iron industry in 1850 produced only 9.1 per cent of French pig iron, and in 1860 only 11.7 per cent. These figures, furthermore, represented the production of the entire province of Lorraine, whereas the figures of 1912 represent only the production of that part of the province which had remained French after the war of 1870.[5]

In the north of France, where the chief departments manufacturing iron were those of the Nord and Pas de Calais, the industry was older than in Lorraine, but was of even less importance until about 1820. The French producers claim that their prosperity then began because the high tariff gave protection against the very strong Belgian industry in the district of Liége. The statement may be questioned. The iron masters themselves mention three other factors that must have been fundamental causes, namely, the adoption of the process of puddling iron with coal about 1820, the discovery about 1832 of important iron deposits near Boulogne, and the great development at about the same time of the coal-beds of the Nord and Pas de Calais, which soon proved to be the richest in France. The region of the north enjoyed other advantages, in the large industrial population which gave abundant labor, and in the ease of transportation both by rail and water. The iron industry of the north grew rapidly and prospered until about 1860, and it developed some of the most important establishments in France, such as those of Denain-Anzin (connected with the most important coal-mining company in the country), Montatire, Outreau, and Marquise.

Beginning with 1860 came a period of hard times, which the manufacturers of the North attributed wholly, at least in public, to the new tariff and British

5. Sidérurgie, pp. 167–190.

competition. They admitted privately, however, that the iron beds of the Nord were exhausted by 1868 and those of the Boulonnais by 1875–78. It is clear that all through the decade from 1860 to 1870 the iron industry of the north was suffering from an increasing scarcity of ore produced within its borders.[6] Its cost of production was increasing rapidly and without relation to the new tariff. The difficulty of getting sufficient ore cheaply appears to have been an important cause of the crisis through which the iron industry of the north passed during the eighteen-sixties, and only a part of the blame, if any, can be attributed to the treaty with England. It is true that the north was the part of France most exposed to the competition of British iron and, after 1861, of Belgian iron also; but, on the other hand, much pig iron was imported from both England and Belgium for refining in the north of France, and those countries sent also considerable quantities of coal and coke. The reduction of the duties on coal and on pig iron was, therefore, helpful to the industry of the north of France, and there is no evidence that this region was flooded with pig or bar iron from England or Belgium. The statistics which were compiled subsequently by the British Iron Trade Association indicate that exports of pig and bar iron to France increased considerably from 1860 until 1865, and then decreased again to approximately the former amount; and they indicate also that at no time were these British exports large enough to threaten seriously the French iron industry, even in the north.[7] The duty of 30 per cent on pig iron imposed by the treaty of 1860 (reduced to 25 per cent in 1864, as the treaty required), while representing a decrease of about 40 per cent from previous rates, gave real protection to the French iron masters.

6. Sidérurgie, pp. 191–223.

7. Ibid.

The region of central France, including the departments of Allier, Cher, Indre, Nièvre, Rhône, Saône-et-Loire, and Loire, was the most important until about 1875. Here a really large-scale industry was first developed and the foundation laid for the great progress of the later nineteenth century. Even during the period when charcoal was used as the only fuel, and iron was smelted and refined in small and widely scattered establishments, the production of this region was important, for it had good forests and several rich beds of ore, such as those of the province of Berry, which were easy to mine. The center did not, however, become the dominant region until coke replaced charcoal as the principal fuel, for other regions had supplies of wood that were even more plentiful; then its real superiority came, because it possessed the richest coal mines in France until the full development of the Pas de Calais and Nord basin toward the middle of the nineteenth century.

The center had the great iron-manufacturing firm of Le Creusot, the most important in France down to 1878, and the workshops of Petin and Gaudet at Rive de Gier on the Rhône, as well as other important establishments, such as Terrenoire. It was the first region in France to develop the smelting of iron with coke in the blast furnace, Wilkinson being brought over from England to Le Creusot at the beginning of the nineteenth century to demonstrate his successful method. It had also the first puddling furnace in France in 1820, and the first French steam hammer in 1841. The center was also the first region to develop the manufacture of steel by the Bessemer and the Martin processes. Its iron masters were leaders in improving both methods of manufacture and equipment and in combining to form associations that would have sufficient capital for manufacturing on a large scale. Like the north, how-

ever, the center began in time to suffer from the exhaustion of its beds of iron ore, so that, before the Thomas-Gilchrist process made Lorraine the dominant metallurgical region of France, it had lost its supremacy. In 1860, however, the center was still the dominant region, so that from it came far less opposition to the treaty of commerce with England than from the north, and far fewer complaints of the competition of British iron.[8]

In sharp contrast to the center, with its large firms and improved methods, was the much smaller district of the upper Marne, a part of the ancient province of Champagne. From this district came the loudest protests against the new tariff policy of France, begun in 1860. These protests were caused by a severe crisis through which the district passed. The local iron industry of the upper Marne had very serious problems to solve; so serious, indeed, that we can say that their solution proved that the influence of the Treaty of 1860, and that of the other treaties that followed it, was not disastrous to the iron industry of France. The upper Marne was not very far from the great market of Paris, and it was near the important iron mining departments of Meurthe and Moselle. It had other advantages, in abundant forests, excellent and plentiful water power, and a considerable supply of good ore, altho this was scattered through a large number of small beds. Before the advent of the railroads and the extensive development of smelting and refining with coal and coke, the upper Marne produced considerable quantities of iron of excellent quality which was highly valued in Paris and other markets, altho its price was very high because the cost of production was great and the cost of transporting the finished product to the market was greater still. As long as the price of iron remained high in most

8. Sidérurgie, pp. 115–116.

French markets the upper Marne prospered without making any arduous efforts to improve its methods and reduce its cost.

With the development of the railroads and of the use of coal and coke as fuel, the situation of the iron industry in the upper Marne changed and a difficult period of transition began. The price of wood, the mainstay of the local producers, rose steadily because of the continued increase in the number of furnaces and foundries using it. The owners of the forests, who were often iron masters themselves, were able to make a handsome profit. The manufacturers who did not own forests, however, suffered from the increasing cost of their fuel, and all the iron masters in common began to feel the competition in the markets of Paris, Rouen, and the northwest, of districts such as the Moselle, the Nord, and the Pas de Calais whose cost of production was much less because of their use of coal and coke, and because the cost of transportation had decreased until it was possible for nearly all districts in France to send their products to distant markets. The upper Marne, on the other hand, began to suffer from the high cost of transportation due to its mountain barriers and the scarcity of railroads within its area. It suffered also from its high cost of production. Iron in the Moselle cost only half as much as in the upper Marne, and coal was much cheaper, so that, altho the quality of Moselle iron sold was distinctly inferior, it was able to compete with the unusually good iron of the upper Marne.

In their complaints to the government, which were loud and frequent between 1860 and 1870, the iron masters of the upper Marne said, first, that they would be ruined by British and Belgian competition, and next, that they had been ruined. Their letters and petitions in 1860 were sent to the Inspector-General of Mines, M.

Combes, who made a report to the Minister of Commerce which is in the government archives.[9] Combes pointed out that, when the producers of the upper Marne complained of the high price of wood, they were themselves responsible for it in great part, for many of them owned forests; furthermore, he showed that at the same time they expressed their fear that the price of wood would fall sharply as soon as British and Belgian competition was felt, and that this would be a disaster to the iron industry. Combes remarked shrewdly that on the basis of this reasoning the discovery of the prolongation of the Sarre coal basin into French territory was a national calamity! Even if these mines were so new that the amount of their production was still uncertain, the new coal-fields of the Nord and the Pas de Calais were very effective realities. It would seem obvious to anyone not an interested party that the competition of coal had to be met and that the only way to meet it was to lower the price of wood. Such a decrease would not be the result of the new commercial policy of the French government, said Combes, but of the revolution in the manufacture of iron caused by the use of coal as fuel.

There is ample evidence to support the correctness of this conclusion. The change in fuel, as we have seen, had made considerable progress before 1860, and iron masters using wood, as those of the upper Marne, were feeling the pressure before the new commercial policy had been thought of by the government. The cheaper French iron smelted or refined with coke was steadily

9. See Petition of Chambre Consultative de Joinville to Minister of Commerce, Jan. 30, 1860, in Archives Nat. F 12–2525; also their Memo., March 10, 1860, in F 12–6222. Petit. Chamber of Commerce St. Dizier Jan. 23, 1860, in F 12–2525, and their letter to Emperor, Jan. 29, 1860, in F 12–6222. Combes' report to Min. of Com., in reply to all above is in F 12–2525. See also letters from Joinville to Min. of Com., April 17, 1862 (F 12–4476D), and April 3, 1868 (F 12–6220).

gaining the ascendancy in the principal French markets, owing to the development of the railroads. The manufacturers of the upper Marne were themselves getting coal from the Sarre, Belgium, and northern France by both rail and water, and were using it generally for refining pig iron, and were even mixing it with charcoal in smelting pig iron itself. The real difficulty was that many of the furnaces and foundries in this region were in the mountains and far from good means of transportation.

The comments that Combes made on the cutlery industry of the upper Marne, one of the chief markets for the iron masters of the region, show what was probably going on in the iron industry in general. The Consultative Chamber of Joinville (the town was too small to have a real chamber of commerce) asked, on the signature of the treaty with England in 1860, that the prohibition of the importation of cutlery be kept in the new tariff; but the request was based only on the personal opinion of four manufacturers of Nogent, the chief center of the widely scattered cutlery industry of the upper Marne. These four had visited Sheffield in 1856, when the French government introduced a bill in the Corps Législatif to remove the principal prohibitions from the tariff. Combes remarked that the Joinville petition, based on their report, carefully refrained from giving any information on comparative methods of production in England and France. The government, however, had such information, and Combes stated that the lower prices in England were due to the use of machinery, good tools, a wise division of labor, and the lower cost of fuel and steel. The manufacturers of the upper Marne should have introduced in their factories the better methods they had seen in England. Other disadvantages that could not be removed could be com-

pensated for by a protective duty of about 30 per cent, which Combes thought high enough for common cutlery for general consumption, as the price of labor was the chief factor in the cost of production and this was lower in France than in England. The opinion of Combes that the cutlery industry of the upper Marne was inefficient was amply corroborated by the testimony of the cutlery manufacturers themselves in the government hearings of May, 1860. It was proved then that the cutlery industry still held to the old domestic system, with the waste of time and effort involved in manufacturing on a small scale in the widely scattered homes of the master workmen.[1]

At the end of his report to the Minister of Commerce on the petitions of the iron masters of Joinville and St. Dizier in the upper Marne the Inspector General of Mines concluded: (1) that, independently of the tariff, the price of iron in France ought to be regulated by the well-placed and efficient establishments using coke as fuel and the new and improved methods of production; (2) that the government had done all it could for the manufacturers of the upper Marne through the building of new railroads and canals, that it was impossible to protect them against the competition of iron made with coal or coke, as in the nearby department of Moselle, and that, even if this had been possible, it would not have been desirable; (3) that the reduction of the duty on iron from the prohibitive rate of 120 francs per ton

1. Enquête, 1860, vol. i, pp. 725, 800–811. Most of the 6000 workers were scattered through the villages around Nogent. They worked alone with inferior tools and without division of labor or supervision. There had been a little progress in recent years, the Nogent region having ten machines run by steam, altho the power given was small; and a few mechanical processes had been invented. A few hundred workers only were in factories. There was complete ignorance of English methods, machines, and prices. The cutlery was generally of inferior quality because the workers did not know how to make good steel.

to 70 francs (about 30 per cent) would not bring down the price of iron, because a large increase in the demand for it by the railroads would result and would tend to raise the price. In any event, he thought, the reduction of the duty was necessary in the general interest of France.

The conclusions thus reached by Combes were justified by the development of the industry of the upper Marne after 1860. There was a difficult period of transition, but it did not prove fatal to the industry. The producers of the upper Marne suffered from the competition of iron made with coke in France, and from that of imported pig iron, which was able to penetrate that district and was mixed with local pig iron to the extent of 20 to 25 per cent. This was stated in a memorandum of the iron masters of Joinville to the Minister of Commerce in April, 1862, and there seems no reason to doubt the accuracy of the statement. On the news of the conclusion of the treaty with England, the price of iron fell from 300 francs to 230 francs in extreme cases; but, as Combes had predicted, it rose again, and by the beginning of 1862 reached 255 francs. One of the chief difficulties was the scarcity of cheap means of transportation. The manufacturers complained that the rates charged by the Est railroad on coal, ore, and iron goods were high, and that the promised waterways were not being completed quickly. The government, on announcing the treaty with England, had promised to carry out promptly a great development in the means of transportation in France and a general reduction of rates both on the railroads and on the canals. It did encourage the construction of new railroads and canals, and did reduce the rates, but made haste so slowly that complaints seem to have been justified. On the other hand, even the iron masters of Joinville admitted in

their memorandum of April, 1862, that the crisis through which their industry was passing was not due wholly to the treaty; and they told the minister that the cutlery manufacturers of Nogent, who had been in great difficulties for eight months, had themselves to thank for most of their troubles because they had not improved their methods of production.

Sixty years later we find the iron industry of the upper Marne flourishing more than ever, and with good prospects for the future. The valuable account of the industry given in the book by the Comité des Forges shows us how the transformation of the industry was brought about. The combination of the reduced tariff on iron in 1860, and the competition of the iron industries of the Meurthe and Moselle departments, which used coke, virtually put an end to iron mining in the upper Marne and killed the charcoal industry. Only one establishment making pig iron survived, through erecting modern furnaces using coke and through using local ore only for mixture with the cheaper ore from eastern France and Luxemburg. But those establishments that were situated near the railroads or the canals, or were placed close to the river, survived and increased their output greatly after changing their equipment and improving their methods. Many learned to specialize in making cast iron, and the manufacture of wrought or weld-iron prospered. Rolling mills were modernized and produced large quantities of wire, sheets, nails, switches, chains, axles, locks, tubes, wheels, boilers, and agricultural tools. The manufacturers, in short, brought their equipment up to date and specialized in the production of goods of superior quality, especially finished parts for machinery of all sorts and sizes.

The iron masters of the upper Marne found that they had three great resources in: (1) their position between

the Department of Meurthe and Moselle,[2] producing raw materials and fuel, and the great market of Paris; (2) their abundant water-power, which increased steadily in value; and (3) in their large supply of skilled labor. Their industry in 1912 had a far larger number of workers than in 1860 and had greatly increased the volume and improved the quality of its output. Save for the inevitable period of transition, the industry was not injured by the new commercial policy of the Second Empire; in fact, there are many grounds for saying that the reforms so bitterly opposed in 1860 were of great and lasting benefit to the manufacturers of the upper Marne.[3]

What effect now did the new commercial policy have on the iron industry of the country as a whole? Information coming from other parts of France was not so abundant as was that from the upper Marne, but sources such as the books of the Comité des Forges and of Amé, Director General of Customs, tell us much; and in addition we have a valuable memorandum of the British Iron Trade Association sent to the Board of Trade in 1876, when the renewal of the Treaty of 1860 was being considered. There were also discussions in 1868 in the French Senate and the Corps Législatif, that brought out facts and figures of great interest. The report of the British Iron Trade Association shows how British exports to France were affected by the Treaty. The duties on ordinary castings in the new tariff averaged 30 per cent as much as they did on most wrought iron. These proved protective and often prohibitive. On pig iron the average duty was 35 per cent; on rails 38 per cent; on bars 29 per cent; and on plates 35 per cent. These duties were modified somewhat by the

2. After the cession of Lorraine to Germany in 1871, the remnants of the Departments of Meurthe and Moselle were combined into one department.

3. Sidérurgie, pp. 119–121.

French system of admitting partly manufactured iron under bond, provided an equivalent amount of finished goods was exported. This was a help to British pig iron. The figures of the Board of Trade show that exports of British pig iron to France for the five years ending in 1860 averaged 74,247 tons; to 1865, 138,116 tons; to 1870, 104,687 tons; and to 1875, 82,400 tons. The statistics of the exports of wrought iron and material for railroads show that in those goods there was not even the temporary increase found for pig iron. There was, in fact, no important change before 1865, and after that a steady decline. The figures, in tons per year were:

Article	Av. for 5 yrs. ending 1860	1865	1870	1875
Bar Iron	[illegible]063	13,607	5,175	88
Rails, Chains, etc.	18,240	13,848	1,864	23
Wire	99	486	291	324
Sheets and Plates	4,956	2,064	1,745	2,321
Cast and Wrought Iron Wares	2,788	7,208	4,262	5,009

The failure to increase British exports of iron goods to France was attributed by the British iron masters partly to the French tariff, which in many cases remained in effect prohibitive, and partly to the great development of the French iron industry. French iron masters had made use of scientific discoveries and had so greatly improved their methods of production that they exported large quantities of iron goods to foreign markets outside of Great Britain, especially locomotives and other machinery.[4]

French importations of iron, nearly all of which came from Great Britain or Belgium, are given by Amé in tons as follows: [5]

4. F. O. 27–2222.

5. Amé, Etude sur les Tarifs de Douanes (last ed. 1876), vol. ii, p. 400. Amé in 1860 was Director of Customs at Paris. His figures are the official statistics of the Customs service. They are difficult to compare with the figures of the British Iron Trade Assoc. because they cover imports from all sources and not from Great Britain alone, altho the only other important source was Belgium.

In 1862 the French government by decree authorized the importation

Period	Pig Iron	Bar Iron	Steel	Total
Av. 1827–36	10,126	5,935	791	16,852
" 1837–46	36,279	3,763	446	40,488
" 1847–56	67,975	17,105	550	85,630
" 1857	95,459	29,373	1,270	126,102
" 1858	63,186	15,706	1,172	80,064
" 1859	43,023	1,736	1,110	45,869
" 1860	28,941	661	742	30,344
" 1861	117,604	12,980	1,892	132,476
" 1862	199,994	80,887	2,282	283,163
" 1863	160,058	12,104	1,809	173,971
" 1864	36,374	2,112	1,058	39,544
" 1865	65,526	3,263	691	69,480
" 1866	72,323	9,326	1,598	83,247
" 1867	80,377	5,789	2,835	89,001
" 1868	18,513	14,038	3,067	35,618
" 1869	6,871	11,910	3,447	22,228

These statistics, while not giving as many details as could be desired, show that there was a considerable increase in the imports of iron between 1850 and 1858, due in great part to the needs of the French railroads and merchant marine. These importations were favored by decrees reducing the duties in general and stating the willingness of the government to reduce them still further in urgent cases. The most important of the decrees was that of October 10, 1855, which authorized for three years the importation of iron for shipbuilding free of duty. The imports under this decree were as follows: for 1856, 23,885 tons; for 1857, 13,766 tons; for 1858, 10,010 tons. Considerable quantities of rails during the later fifties were admitted on payment of 60 francs per ton, which was half of the normal duty at that time. These imports amounted to 39,948 tons in 1856; 7841 in

under bond of partly manufactured iron provided an equivalent amount was exported in finished goods. Before 1862 the law required that exactly the same pieces of iron imported under bond be thus exported in the form of finished goods. We do not know how much pig iron was sent into France in bond, and this amount may have been large beginning with 1862. We do know that there were loud complaints from many iron masters in France of an extensive trade in the sale of permits to import such iron.

1857; and 1260 in 1858.[6] The figures indicate that in 1856 a large part of the imports of iron came in either free for shipbuilding, or in the form of rails at a reduced duty. For 1857 and 1858 the imports of iron that came in free or at a reduced duty amounted to only a small part of the total. For the imports between 1860 and 1870 we lack such detailed information; but the figures of the French customs service indicate that the duty on bar iron of 70 francs per ton in 1860 (effective 1861) and 60 francs in 1864 proved almost prohibitive, and this is confirmed, as we have seen, by the statements of the British iron masters. For pig iron the imports were unusually large for three years only, that is in 1861, 1862, and 1863. If we can say that these imports were due to the reorganization of the French iron industry and the efforts of the French manufacturers to adjust themselves to British and Belgian competition, the period of transition was not long. After 1863 the duty on pig iron imposed by the Treaty of 1860 seems to have given effective protection.

In attempting to determine the results of the Chevalier-Cobden Treaty of 1860 on the French iron industry we must not regard the treaty as the sole, or even the principal, cause of the reorganization of that industry. It would be easy to give figures proving that the smelting of iron with wood decreased notably after 1860; that a large number of furnaces, foundries, and forges that were badly situated or that produced on a very small scale, succumbed; that the surviving establishments using coal and producing on a large scale grew larger and more important. But two causes were more important than the treaty, and their influence was felt before 1860: the increasing use of coal in the smelting

6. Wolowski, Reforme douanière. Journal des Economistes, 2d series, vol. xxv (Jan. 1860) p. 435.

and refining of iron, and the building of the railroads. Both the difficulties from which the iron industry suffered after 1860, and the benefits felt by French industry as a whole as well as by French trade and agriculture, were due far more to the increasing use of coal and the improved means of transportation than to the change in the country's commercial policy.

The Anglo-French Treaty of 1860 was not, then, the principal cause of the reorganization of the iron industry in France because that reorganization began long before 1860. The difficulties of the manufacturers were due largely to the fact that the treaty caught them in the midst of that reorganization, and that it caught them suddenly like a bolt from the blue. They were loud in their denunciations because they hoped that they could influence the government to keep the maximum duties which the terms of the treaty permitted, — and herein they were largely successful, and because they hoped to conceal their own shortcomings and greed. Their real aims were clearly understood by the government, and not even the Emperor was deceived when the iron masters spoke feelingly of the protection of national labor — the perennial argument, which had proved effective under the Restoration and the July monarchy, and was again to prove effective under the Third Republic. Combes wrote the Minister of Commerce, in 1860, that the real object of the Comité des Forges, under the presidency of Léon Talabot of the Denain company, was to keep up the price of iron by whatever arguments or threats seemed to them most likely to be effective.[7]

What, in sum, were the positive effects of the treaty of 1860 on the iron industry of France? We have studied the negative effects; clearly, it did not ruin or even injure seriously the iron industry; but did it ac-

7. Archives Nationales F 12–2514.

complish anything positive? These questions must be considered in the light of the aims of the principal author of the treaty, Michel Chevalier. We know from his private papers and from an important document in the National Archives written by him,[8] that he did not regard the treaty as an end in itself, but as part of a plan for the reform of the entire economic system of France; one which should include, among other things, a great development in the means of transportation and a notable reduction in their cost. He wished to lower the tariff in order to stimulate French industries to improve their methods and increase their production, so that they could lower their prices; and of all the industries in France he considered that of iron the most important and the most backward. It should be remembered that he was not merely an economist, but also a skilled engineer, with professional knowledge of the iron industry in France, England, and the United States. He put greatest emphasis on cheap iron, because he wished iron to be used freely in all industries and in agriculture. This was his fundamental object when submitting to the Emperor, in the autumn of 1859, his plan for the reform of the economic system, in which the treaty with England was to be the principal feature. We can say that this object was achieved. The treaty did help to bring down the price of iron and, in time, of machinery of all sorts for industry, agriculture, and transportation. It was successful, in that it helped to bring about the full development of the industrial revolution in France.

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8. See the writer's Chevalier's Plan of 1859; the Basis of the new Commercial Policy of Napoleon III, in American Historical Review, Oct., 1924.

REVIEW

ESSLEN'S POLITIK DES AUSWÄRTIGEN HANDELS[1]

PROFESSOR ESSLEN'S book will not fail to maintain the reputation established by his previous publications, and especially by his book on the Law of Diminishing Returns. The present volume gives a well-rounded treatment of the theory of international trade, of the actual conduct of trade between nations, of commercial policy and its concrete working. It is not a "contribution," or monograph, or isolated discussion on a particular phase or phases. It justifies its title as a Lehrbuch; and the German Lehrbuch is something more than a textbook — it is a treatise. This one has the merit, too, not always found in the German Lehrbuch, of being compact and restrained, not swollen to undue dimensions. The exposition is orderly, the style fluent and straightforward. The reader's task is made as easy as possible. In every way it is superior to the common run of what appears on the subject.

The volume is divided into six parts, which may be grouped in two main divisions. The first division, containing parts I and II, is on the theory of international trade and international payments. The remaining four parts (in the second division) are on commercial policy, the several topics being: protection and free trade; commercial treaties and the like; the tariff histories of leading countries; current German problems, and especially protection to agricultural products.

Professor Esslen's position is that of the detached ob-

1. Die Politik des Auswärtigen Handels. Ein Lehrbuch. Von Joseph Bergfried Esslen, Professor a. d. Univ. Göttingen. Stuttgart, F. Encke. Pp. 368.

server — of the man of science. He shows no bias as regards either theory or its application. As might be expected from a follower of Brentano (the book is dedicated to that scholar, as a supplementary tribute for his eightieth anniversary), the intellectual bias is against the ordinary protectionist attitude. But the treatment of the protective controversy is as objective as that of the theory of international trade, on which the views diverge substantially from those of the Ricardian school.

As regards protection and free trade, our author has little patience (p. 314) with the attitude common among German economists of the pre-war days — that the choice between the two involves no question of principle or theory, but is a matter of mere expediency, to be decided without prejudice according to the conditions of the time for each country; a sort of non-committal attitude, coupled often enough with a gesture of contempt for the theorizers. Professor Esslen remarks that there can hardly be said to be a free trader on principle among the German economists; which is doubtless true, in the sense that the old-fashioned utopian free trader has quite disappeared. It is more noteworthy that, as he sees it (p. 330), academic opinion on the immediate questions of commercial policy now confronting his country is divided as never before. His own view, categorically stated (p. 118), is that complete free trade is now the only possible policy for Germany, and that duties on grain — the crucial question — are especially indefensible. But this conclusion rests not only on the rejection of the vulgar or pseudo-scientific arguments for protection, but even more on the special conditions confronting Germany under the settlement of 1924. These conditions are examined with great care; the discussion of the present German controversy regarding grain duties being particularly full, and also particularly good. It is inevitable that Professor Esslen should be somewhat under the shadow of the time (the book was completed in 1925), and that his sombre feelings on the economic "servitude" now imposed on Germany should affect his discussion of general problems; no one can write with complete detachment from the exigen-

cies of his own day and his own country. Much that he is led to say with reference to the conditions of 1925 may be obsolete by 1930. But preoccupations of this kind do not distort his general views. His conclusions are those of an open-minded and well-informed judge, not wedded to any doctrinaire opinions, or disposed to any over-refinements of theory.

The accounts of the tariff histories of different countries in the fifth part are written in the same spirit, and are excellent. The countries covered are Great Britain, Germany, France, the United States, Russia. The chapter on France is the briefest, and the least adequate. That on Germany is full, but not at all too full, and throws light on many points whose significance a foreigner would not easily grasp. Throughout this part there are not only accounts of the legislative changes and the conditions under which they came about, but discriminating remarks on the economic effects of the several tariff policies. Particularly illuminating is the verdict on the hot-house Russian tariff of pre-war days. The German grain duties — their history, economic effects in the past, possibilities for the future — are the sole subject of the last (sixth) part. So far as concerns anything in the way of propaganda on current issues, it is this topic to which the book is chiefly directed and with which it naturally closes.

The theory of international trade and of international payments is taken up in what I have called the first division of the book (parts I and II). Here I find the treatment less satisfactory; and this is the case also with the treatment, in the subsequent pages, of some of the more intricate questions involved in the protective controversy.

Part I gives a statement, very brief, of the theory of international trade. The conclusion reached is that there is no difference between domestic trade and international trade. In both there is at bottom the bartering of goods for goods. In both the exchanges rest on differences between the subjective valuations of the exchangers, and bring a gain of utilities (*Brauchbarkeiten*) to all sellers and buyers. In neither are "equal values" exchanged. But — so runs the argument

— it was a relation of equal values that Ricardo assumed; and in his failure to see the gain in satisfactions which accrues throughout to every buyer and every seller, lies the falsity of his whole reasoning on prices and values, and so of his reasoning on international trade. All of which, I submit, is beside the point. Ricardo was well aware of the distinction between "value" and "riches"; but it had nothing to do with his theories on domestic trade or international trade. The figures which Professor Esslen gives (p. 19) by way of showing that subjective valuations of buyers and sellers differ, — they are of the kind familiar in the literature of theoretical economics and especially in the writings of the Austrians, — seem to me to have no bearing on the question whether Ricardo was right or wrong in his analysis of international trade. What Ricardo had in mind — and all his successors too, as regards this topic — was the pure and simple phenomenon of "objective exchange value": how physical quantities of goods are exchanged, and how far these "rates of exchange" are determined by the quantities of labor applied in making the goods. It is no doubt a debatable matter whether there is a difference between domestic and international trade; but the analysis of subjective valuations has nothing to do with it. I will not labor the point. Professor Esslen touches elsewhere on the familiar question whether the mobility of labor or capital is more free within a country than between countries. In maintaining that it is not, he is in good company, and has much to say that is valid. But this line of reasoning obviously is quite different from the other.

On trade balances, international payments, and international price movements, Professor Esslen rejects almost *in toto* the Ricardian theory on the distribution of the precious metals. He finds the "classic" theory naïvely simple and inaccurate as regards the balance of trade. Imports and exports do not tend to balance; the "invisible" items are large, and commonly bring about either an excess of imports or one of exports. I cannot but believe it curious that so many distinguished German economists, Professor Esslen among them, should think these familiar phenomena incon-

sistent with what is called the classic theory. They fit quite easily into that body of reasoning; which indeed is supplemented and improved by their inclusion, but is not substantially altered. In this line of attack there is nothing dangerous for the good old doctrine. True it is that consideration of the non-merchandise items in international payments leads to certain corollaries as regards international prices and the terms of trade between nations, which add to the theory of the case a novel element. But refinements of this kind are not touched at all by any of the recent German writers, and indeed seem to be beyond their ken.

More weighty are the strictures which Professor Esslen, in common with many other writers of various nationalities, passes on the traditional version of the mechanism of international payments — the flow of money from country to country, the supposed influence on price levels, the eventual reflex effects on exports and imports. His discussion of these topics is much more elaborate than that of the theory of international trade in the first part. His second part, in which they are taken up, runs over nearly a hundred pages, and considers the balance of trade, the foreign exchanges, discount policies, gold reserves and gold flows, security movements, the policies of the great banks and of governments. There are instructive and interesting comments (partly based on Somary's book of 1916, *Bankpolitik*) on the London money market, and the conditions in Germany, France, Austria, Russia, Italy, before the war, during, and after it. The general conclusion is that the kind of analysis which the classical school applied does not fit the facts. There is no such quasi-automatic maintenance of a balance of trade as it assumed; no tendency for a flow of specie to set in when the balance is disturbed, and to bring into operation forces which then restore equilibrium. Even under the conditions which happened to prevail for a few decades before the great war, when the leading countries did exert themselves to maintain the gold standard, the supposed automatic working of that standard is not to be found; still less does anything of the kind appear on a longer view of the past, or seem

likely to appear under the conditions of the present or the visible future.

It is to be freely admitted that here we are on debatable ground. Just how the mechanism of international payments affects the substantive course of international trade — the merchandise movements; just what are the limitations (are there any?) on the deliberate influencing of imports and exports and of trade balances through discount rates, loans and credits, government action, without any flow of specie — on all this we must speak with caution. True, not much is gained toward a solution by the sort of criticism which Professor Esslen, again in accord with many of his countrymen directs against the "quantity theory." In the naïve form which he has in mind, surely no one holds it. But, on the other hand, no one can affirm that we are on certain ground as regards the way in which changes in price levels between countries are brought about, or the way in which trade between countries affects the movements of prices and is affected by them. It is not easy to make out just what is Professor Esslen's own view on these fundamental matters. He summarizes his conclusion thus (p. 93): "The final equalization [*Ausgleich*] of the balance of payments took place in the decade just before 1914 through differences in the rates of interest between the several economic units, and through differences thereby induced in the quotations of international securities and in the prices of goods." But just *how* the prices of goods were influenced, he does not tell us. The doctrine seems to be negative; at all events, gold movements are not supposed to give a steady clue.

I cannot but feel that something more positive, something more in the way of a reasoned explanation, is called for than these pages contain. No doubt the relation between the underlying forces and the operating mechanism was unduly simplified by the earlier British writers; and the same criticism is not unjustified against eminent writers of later date, such as Marshall, Edgeworth, Bastable. In this part of the economic field, as in some others, there is a curious contrast between the British and the German traditions; curious, be-

cause not in accord with the general intellectual traditions of the two peoples. The British treatment of international trade is abstract, deductive, severely reasoned, intent on logical refinements and subtleties; but pays too little attention to the details and the realities. The German treatment is realistic, descriptive, attentive to the facts; but often fails to see the forest because of the many trees. Professor Esslen's book by no means belongs with those in which the trees only are viewed; but with all its fullness, discrimination, good sense, a more constant eye to fundamental principles and long-run effects would add to its merits.

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NOTES AND DISCUSSIONS

DEPRECIATION AND REPRODUCTION COST

PROFESSOR BONBRIGHT'S paper on "Depreciation and Valuation for Rate Control," in this number of the Journal, will do much to remove the misunderstandings which envelop the subject with which he deals. I am gratified to know that our positions are not so far apart as they once appeared to be. He is right in saying that I have explained that in my paper on "Depreciation and Rate Control" I assumed "some form of the historical-cost basis," and that my argument was not intended to hold good "when a reproduction-cost standard is applied." Taken by itself, however, this statement may be misleading.

I looked at both reproduction cost and original cost as affording merely working methods, not standards or principles of valuation. "If the accounts of a company," I said, "had been subject to regulation from the beginning . . . valuation would be unnecessary. The accounts would tell the story. Lacking such accounts we turn, perforce, to the value (there is no better word) of the tangible properties as affording about the only available evidence of the amount of the investment entitled to a return." [1] I assumed throughout that, whatever the technique it employs, the object of public valuation for rate control is to determine the amount prudently invested in providing a public service. My principal thesis was that the circumstance that a public service corporation with large and varied properties had not built up a reserve as an offset to "accrued depreciation" did not necessarily mean that its proprietors had repocketed part of their investment.

If it is held that a public service company is entitled to a

1. Quarterly Journal of Economics, xviii, 656.

fair return upon its "prudent investment," and if reproduction cost is taken merely as partial evidence of the amount of capital prudently invested, one can consistently hold, as I held, that "In valuation for purposes of rate control no deduction should be made on account of the depreciation of large and varied properties, except for depreciation allocated to a period in which depreciation accruals were regularly charged to operating expenses." The reasonable expectation of the planners of an enterprise that provision would have to be made only for realized, not for accrued depreciation, must be assumed to have figured in the supply price of capital. But if it is held, as the Supreme Court recently held in the Indianapolis Water Company case, that the present cost of constructing a plant is in itself a "fair measure" of the amount upon which the company is entitled to a fair return, the case against deducting depreciation is not valid. The reason is that the cost of a new plant *includes* the cost of replacing worn equipment with new equipment. For a term of years a new plant would face smaller annual replacement costs than the old plant has to face. Professor Bonbright is clearly right in saying that "*any* notion of *physical* valuation, if it has any meaning at all, necessarily implies a deduction from cost-of-reproduction new, to allow for accrued depreciation and for obsolesence." [2]

In 1914 it was possible for me to say: "Under American conditions the difference between original cost and replacement cost as a standard of valuation is not likely to be large," especially in view of "the common practice of averaging prices over a period of five or ten years." The subsequent

2. Professor Bonbright hits so many nails squarely on their heads that it may be ungracious to suggest that he has driven in one or two superfluous ones. That the "theory of constant renewals" does not always hold good is a point to which I specifically called attention. That unless a depreciation reserve is set up "early customers will pay less and later customers will pay more toward the upkeep of the property than they should fairly pay" is a conclusion not confirmed by the history of the earnings of public service companies in their earlier and their later years. There is no reason why the sums customers contribute in any one year should be construed to be "payments" for the outlays made in that particular year.

advance of prices has put a new face upon this problem. Reproduction cost is often much larger than original cost, and has lost most of its usefulness as evidence of "the amount of the investment entitled to a return." Today the adherents of the reproduction-cost formula are really holding that a general and unforeseen rise of prices and costs entitles a public service company to write up its property account.[3] This is not a wholly untenable position, altho the real issue involved — whether a general rise of prices gives the company a claim to larger money earnings — is clearer if it is approached without dragging in the reproduction-cost formula.

Competitive enterprises, in general, appear to be able to increase their money profits so as to keep abreast of (and for a while ahead of) the diminished purchasing power of money. Should the regulated corporation be penalized? Should it be compelled to see its "real income" shrink in a period of rising prices? I shall take space for only two observations. (1) A fixed amount of the money income of railroads and of other public service corporations is assigned by inflexible contracts to bondholders, whose "real incomes" cannot but shrink as prices rise. Permitting a company to increase its total money earnings in proportion to the increase of the cost of reproducing its plant would generally result in a more than proportionate increase in the value of stockholders' equities. The present financial organization of many public service corporations is such that excessive gains would accrue to a relatively small number of persons. (2) Just how permanent a general change of the price level is cannot be foretold with any certainty. It is absurd to shift the amount of a company's supposed "investment" up or down with every substantial change in the aggregate cost of reproducing its physical properties. Doubtless there are occasions when changes in the level of prices may call for modifications of the amounts particular companies are allowed to earn. But it is simpler and better in every way to introduce an element of elasticity into the notion of what constitutes a "fair rate of return." A

3. Cf., e. g., F. G. Dorety, "The Function of Reproduction Cost," Harvard Law Review, xxxvi, 181 (December, 1923).

fair rate may be higher under some circumstances than under others. The amount of the past investment ought to be established once for all.

The commissions, federal and state, are quite as much to blame as the courts for hardening the physical-inventory method of getting evidence of the amount of a company's capital investment into a reproduction-cost-minus-depreciation formula of valuation. The rule laid down in 1898 in Smyth *v.* Ames with respect to the "matters for consideration" in determining "the value of that which the company employs for the public convenience" was none too broad. What it lacked was a better name than "value" for the quaesitum to which the various "matters for consideration" were supposed to point. In particular instances, as where a remorseless application of the reproduction-cost-minus-depreciation formula would immediately have forced a public utility company into a receivership, state commissions availed themselves of the elasticity of the Smyth *v.* Ames rule. But in dealing with prosperous companies some of the commissions came to rely more and more upon reproduction cost minus depreciation as the principal factor in determining the capital sum upon which a fair return was to be permitted. The Interstate Commerce Commission, in its railway valuations, has done no better. [4]

Various circumstances, probably, are responsible for the ascendency of this particular "matter for consideration." Reproduction costs, as established by a corps of engineers, have an air of precision, and lend themselves to rule-of-thumb methods. The solution of certain problems of taxation was made easier by separating "physical value" and "franchise value." Reproduction cost minus depreciation appeared to be an appropriate measure of "physical value" for purposes of taxation. And if for taxation, "why not for rate control?" The original costs of physical properties were often difficult to get, while a just estimate of historical cost or prudent investment could not be made without carefully weigh-

4. See H. B. Vanderblue and K. F. Burgess: Rates, Service, Management (1923), p. 347.

ing in each case a variety of pertinent considerations. Reproduction cost minus depreciation appeared to afford a safe mooring, particularly as (before 1917) it rarely gave results which could be held to be unduly favorable to the companies. But whatever the importance of these circumstances, the upshot was that a task for accountants and economists became a task for engineers.

The cases that went up to the courts from the commissions were often in such form that the issue turned upon a commission's right to use the reproduction-cost standard, or upon some aspect of its use of that standard. This should be kept in mind in interpreting the decisions of the courts. Recently, however, the courts appear to have begun to close the door to other matters for consideration than reproduction cost minus depreciation. The opinion of the Supreme Court (as distinguished from the result) in the Indianapolis Water Company case comes close to being a *reductio ad absurdum* of the reproduction-cost rule. It is to be hoped that sounder counsels, such as were voiced by Mr. Justice Brandeis in his dissenting opinions in the Southwestern Bell Telephone Company and Indianapolis Water Company cases, will prevail.

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THE DISTRIBUTION EQUILIBRIUM UNDER THE SPECIFIC PRODUCTIVITY THEORY

IN the usual exposition of the theory of marginal productivity it is customary to discuss the productivity of a single factor of production, assuming constant cost for the other factors. The analysis is then repeated for each factor in turn. Such an exposition can never quite free itself from the suspicion of circular reasoning. On the other hand, a more fundamental treatment, casting aside the convenient tool of analysis provided by a stable money economy, is verbally very difficult. It can be carried through, as was demonstrated

by J. B. Clark, but the heroic simplification necessary, such as the assumption of a fixed supply of all factors, and the involved nature of the discussion even after such simplification, make the result almost less satisfactory to most persons than the more superficial treatment. Such a mathematical treatment as Bowley's [1] perhaps provides a logically complete theory of distribution. The mathematics is, however, not easily followed through by anyone not accustomed to thinking in terms of the calculus, and the equations dealing with distribution follow and depend upon those concerning value in exchange. Under these circumstances the writer has been led to seek a statement in mathematical symbols which should furnish a complete determination of distribution at equilibrium under the assumption of the specific productivity theory. Once we assume that the value in exchange of factors of production depends upon their specific derived utility, which is defined as the product of marginal productivity times marginal utility of the product, we need make no further reference to exchange value. All that is needed is a statement of the equilibria that determine how much of each factor is used and what amount of each commodity is produced. Our formulae will be the familiar Carverian [2] formulae of the "$ax + y$ produces p" type (recast for convenience in slightly different form), expanded into a body of autonomous equilibria.

It will be sufficient to deal with only two factors of production and two commodities, since there is nothing in the synthesis which is not applicable to any number. To begin with, assume two factors of production producing a single homogeneous product. Let P with a subscript and fractional exponent be the marginal productivity of the factor indicated by the subscript when used with the other factor in the amounts indicated by the exponent. Thus $P_x^{x:y}$ is the productivity of factor x when x quantity is used with y quantity of factor y; and $P_x^{x+1:y}$ is the productivity of x when $x+1$ units are used

1. A. L. Bowley, The Mathematical Groundwork of Economics, Oxford, 1924.
2. T. N. Carver, The Distribution of Wealth, chap. 2, passim.

with y units of factor y. Let $W^{x:y}$ be the whole product of x used with y. Then, when the units in which x and the units in which y is measured are very small,

$$P_x^{x:y} = W^{x+1:y} - W^{x:y}$$
$$P_y^{x:y} = W^{x:y+1} - W^{x:y}$$

and $$xP_x^{x:y} + yP_y^{x:y} = W^{x:y}.$$

Let a be a number just greater than unity. Then either

(1) $P_x^{ax:y} > P_x^{x:y}$ and $P_y^{ax:y} > P_y^{x:y}$, or

(2) $P_x^{ax:y} < P_x^{x:y}$ and $P_y^{ax:y} > P_y^{x:y}$, or

(3) $P_x^{ax:y} < P_x^{x:y}$ and $P_y^{ax:y} < P_y^{x:y}$.

Within range 2, P_x and P_y are both positive quantities.

Where one factor is limited in supply, they will be combined in any ratio in range 2. Where both factors are limited in supply, they will be combined in a particular ratio within range 2.

If both factors are absolutely limited in supply, they will be combined in the ratio of their total supplies. If units of both are so defined that

$$P_x^{x:y} = P_y^{x:y},$$

then $$W^{ax:y} < W^{x:y}\left[\frac{ax+y}{x+y}\right]$$

and $$W^{x:ay} < W^{x:y}\left[\frac{x+ay}{x+y}\right]$$

If both factors have a disutility cost and units of both are so defined that, where D_x^x is the marginal disutility cost of x units of factor x,

$$D_x^x = D_y^y$$

they will be combined in such a ratio that

$$W^{ax:y} < W^{x:y}\left[\frac{ax+y}{x+y}\right]$$

and $$W^{x:ay} < W^{x:y}\left[\frac{x+ay}{x+y}\right]$$

hence $$P_x^{x:y}\, P_y^{x:y}.$$

The total quantities employed will be such that, where $U_p^{x:y}$ is the marginal utility of the product of x and y

$$axD_x^{ax} + {}_{ay}D_y^{ay} > W^{ax:ay}\,U_p^{ax:ay} = aW^{x:y}\,U_p^{ax:ay};$$

and, where b is a number just less than unity,

$$bxD_x^{bx} + byD_y^{by} < bW^{x:y}\,U_p^{bx:by};$$

hence $$xD_x^{x} + yD_y^{y} = W^{x:y}\,U_p^{x:y}$$

If x has a disutility cost and y is absolutely limited in supply, they will be combined in such a ratio that

$$D_x^{x} = P_x^{x:y}\,U_p^{x:y}.$$

and the total supply of y will be used.

The complete case in which two factors of production are used in the production of two commodities may now be taken up. Let c be the number of units of x and d, of y used in producing m units of a commodity m, and let e be the number of units of x, and f of y used in producing n units of a commodity n. The total amount of the factors used will be so distributed that, where r is a small quantity,

$$\begin{array}{llll}
U_m^{(e+r)x:dy} - U_m^{cx:dy} < & U_n^{ex:fy} & - U_n^{(e-r)x:fy} \\
U_m^{cx:dy} - & U_m^{(e-r)x:dy} > & U_n^{(e+r)x:fy} - U_n^{ex:fy} \\
U_m^{cx:(d+r)y} - U_m^{cx:dy} < & U_n^{ex:fy} - & U_n^{ex:(f-r)y} \\
U_m^{cx:dy} - & U_m^{cx:(d-r)y} > & U_n^{ex:(f+r)y} - U_n^{ex:fy}.
\end{array}$$

Hence, where U_x is the derived specific utility of x,

$$U_x^{m} = U_x^{n}$$
$$U_y^{m} = U_y^{n}.$$

Under these conditions, the equations developed for homogeneous product are applicable and are sufficient to determine equilibrium.

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SINKING FUND AND COST: CRITICISM OF BYE'S ANALYSIS [1]

In an article appearing in the November (1926) issue of the *Quarterly Journal of Economics* on "The Nature and Fundamental Elements of Costs," Professor Bye has allowed an error concerning the treatment of sinking funds to creep in. Nor, indeed, is the error an uncommon one. It grows out of a technical situation that in popular conception is frequently misinterpreted. It is in the hope of eliminating the misinterpretation in this particular paper, and in order to analyze very briefly the nature and consequence of the misconception, that this note is written.

After demonstrating that depreciation may be properly classified as a cost of production, the following statements appear (pp. 53, 54): "The provision of a sinking fund to retire bonded or other indebtedness in a business is essentially similar to this matter of depreciation. It is a cost in the same sense, in that it is a device for making the present flow of commodities bear their share of the cost of the original capital which their production required. In the long run, the production of the commodities concerned could not be sustained unless the sinking fund necessary to maintain the capital intact were provided."

Perhaps the best way of analyzing the issue is to adopt the general approach of the accountant. In an earlier paragraph Professor Bye has pointed out that "depreciation is just a bookkeeping device for making a commodity bear the cost of the original fixed capital which was required to produce it." This is the orthodox and seemingly quite correct view. The charge for the periodic depreciation is made as one of the

1. The arguments here presented are, to be sure, not unfamiliar to accountants. They may be found in almost any text on corporation accounting. To mention but two: W. M. Cole: Fundamentals of Accounting, pp. 333–337; W. A. Paton: Accounting, pp. 732–733. See also account 552 in the Classification of Income, Profit and Loss, and General Balance Sheet Accounts for Steam Roads, issue of 1914.

costs of obtaining the revenue for the period, the credit or credits being made to the accounts for the particular assets whose decrease in value is thus intended to be recorded, or to some accounts subsidiary and supplementary to these. Thus, by this entry, is recorded the decrease in the value of the assets that this fiscal period is expected to bear, and there is included in cost the total amount of the depreciation. Whence comes, then, the necessity for an additional charge.

Perhaps an illustration would be of assistance in defining the issue. Let us assume that an entrepreneur entered business borrowing no capital. Among his costs would appear depreciation on the various fixed assets, but certainly there would be included no charge for the amortization of his own investment in the enterprise. Now let us assume a second entrepreneur conducting a business of exactly the same size, but who found it necessary to borrow capital. Among the costs of this enterprise would appear, as in the other, a charge for depreciation, and, following Professor Bye, a charge for interest on the borrowed funds. If interest on the total investment be considered a cost, and we assume further that the rate on the borrowed funds is identical with the "reasonable return" on the investment of the proprietors, the total interest cost of the second enterprise would be exactly equivalent to that of the first. In the second case, however, suppose there had been provided a sinking fund and sinking fund reserve for the amortization of the debt, with the provision that additions to the sinking fund be made from earned assets. In strict accordance with Professor Bye, when credits were made to the sinking fund reserve account, the debits would be made to cost. In this event the second enterprise would have higher costs than the first by the amount of the charge. This would seem clearly to be duplication. Suppose a fixed asset, costing $10,000, were expected to have a life of two years and had been bought with borrowed funds for which a sinking fund had been provided. The depreciation charge would be $5,000 each year, and at the end of two years the entire cost of the asset would have been charged to cost. If, in addition, a charge of $5,000 is made each year to cost

because of the requirements of the sinking fund, there has been charged to cost in the two years a total of $20,000 for a machine costing but one half that sum.

It should be pointed out that the sinking fund is an asset, hence it is not necessarily affected by profits. A sinking fund can be accumulated without reference to profits, though perhaps the more usual way is to add to the fund only earned assets. The fund is increased by debiting it and crediting some other asset account. In conjunction with the sinking fund account the sinking fund reserve account is frequently used. If the agreement is that the reserve account be increased only out of profits, the entry is a debit to net income and a credit to the reserve account. This in no way decreases the profit for the period: it represents one method of distributing that net income. The reserve account is really an appropriated surplus account. When its purpose has been accomplished, an entry is made debiting the reserve account and crediting surplus, hence it ultimately returns to the place from which it originally came. The creation and operation of the sinking fund and sinking fund reserve accounts result in compelling the stockholders to buy out the interest of the bondholders or noteholders, as the case many be, through the retention of profits and the corresponding increase of assets.

It may also be noted that a depreciation fund is usually interpreted to mean the segregation of assets to provide for the replacement of the assets disappearing in the processes of production. The fund is entirely separate from the periodic charge for depreciation. It represents simply a managerial plan for providing ready funds for renewal. The charge for depreciation will conserve in the business values equivalent to those disappearing in production, provided, of course, profits are earned. The assets so conserved may be of almost any conceivable sort. All that is accomplished by the use of a depreciation fund is that assets so retained will be of a particular kind, usually readily marketable securities, so that, when the necessity for replacement arises, readily available funds will have been previously provided.

In summary, then, it is argued that the maintenance of a

sinking fund or of a depreciation fund has no bearing on cost of production. They represent, rather, devices frequently found convenient in facilitating financial administration. The periodic charges to depreciation are costs, the additions to the depreciation fund are not, and the operation of a sinking fund or sinking fund reserve involves cost of production in no way whatsoever.

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